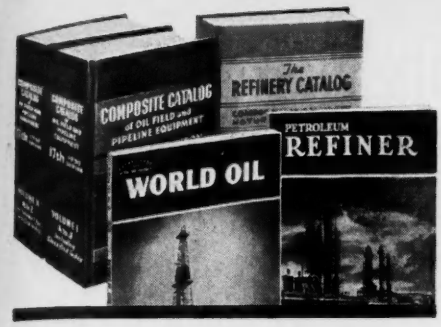

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WORLD OIL and The COMPOSITE CATALOG
for the drilling-producing-pipe line industry

PETROLEUM REFINER and The REFINERY CATALOG
for the refining-natural gasoline industry

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CIRCULATION DEPARTMENT
CLINTON S. QUIN, JR., *Manager*

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Don't miss

the 1950 Review-Forecast Issue of WORLD OIL—to be published February 15. If you are not now a subscriber to WORLD OIL in your own name, use the personal order form on page 183.

WORLD OIL

Established 1916 as THE OIL WEEKLY

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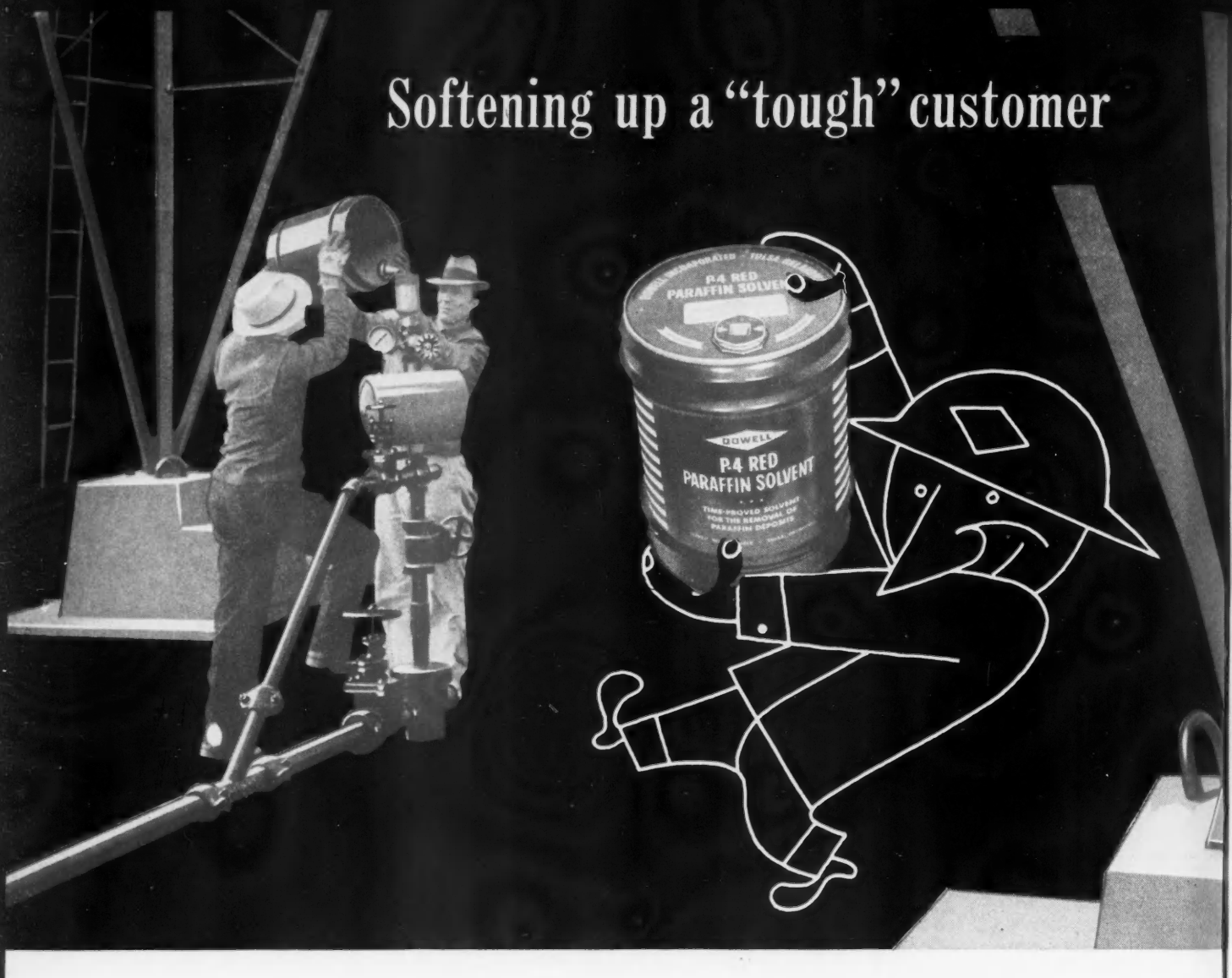
Softening up a "tough" customer



DOWELL PARAFFIN SOLVENTS are first aid for production problems caused by paraffin deposits.

For a "tough" situation where paraffin deposits are gumming up the works, choose economical, time-tested Dowell Paraffin Solvents, designed to *increase production* in pumping or flowing wells by dissolving the toughest paraffin—even complicated by impurities such as salt and sand.

For example, the production of a dually completed, high-pressure well was cut by paraffin deposits in the tubing and annular space between tubing and casing. The well was shut in and Dowell Paraffin Solvent lubricated into the casing and tubing. The solvent was allowed to remain in contact with the paraffin deposit for several hours. *Result:* After one small Dowell Paraffin Solvent treatment, *the flow increased from 150 to 195 b.o.p.d.!*

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Ask your nearest Dowell station for complete information on these Dowell services and products: Acidizing, Electric Pilot Services, remedial Plastic Service, Chemical Scale Removal Service for heat exchange equipment, Jelflake, Paraffin Solvents and Bulk Inhibited Hydrochloric Acid.

"Petroleum Promotes Progress"

Look to
DOWELL
FOR OIL INDUSTRY CHEMICAL SERVICE

CAN A PENSION BE A RACKET?

ALL OF US rather like the idea of a pension. The prospect of security involved appeals to us, and the idea that our hard service is being rewarded after we stop work is more pleasing.

Any one of us, and that should go for the lowest paid employe and the highest as well, would bitterly resent some third party coming in and using our pension to force us to do something we might not want to do.

If a company can and does make a pension agreement with us, we want that agreement to be carried out to the fullest extent of the ability of the company. I think that most of us would grant that a certain degree of loyalty and decency in doing our jobs is a necessary condition to our holding the job—but we certainly would raise sand if we thought that the company was firing us in order to save paying a pension.

And, in the pensions with which we are acquainted, a company wouldn't profit from firing an employe to keep him from getting a pension because all pension systems we know about provide that the money paid in for pensions can NEVER go back to the company.

But how about some third party—the guy down at the hiring hall, or the union official or the union itself—stepping in and interfering with our pension rights after we got 'em?

Ah, that's the rub—because that is just what some unions are getting ready to do. They want to get control of the pension money so that they can whip the employe in line with still another weapon—his right to his pension.

Is this an imaginary fear?

Hardly.

The president of the Lithographers' Union, on his President's page in the *Lithographer's Journal,* while using nearly a page of words for sugar coating, says:

"We have already proposed, in some of our areas, a clause for our contracts which we think can work out for the benefit of this industry; a setting-up of a joint trusteeship to create a fund which will bind together the various Local areas in order to create a pension fund which will give our members the freedom of working in whatever area they want to and continue to hold their equity in a pension fund. This requires complete cooperation of all Locals in International thinking. No Local is sufficient in itself to rely on its own economic strength and resist this great tie which binds us together in a great democratic organization, and we believe that however long it may take us, progress will only be gained by moving in the direction of creating an International base for a pension fund rather than allowing individual employers to bind employes to their shops or individual Locals to bind members to their particular Local area."

What this union wants—and we'll grant that it is one of the more leftist—is control of the pension fund. Then if the employes don't line up as to what the labor bosses want, well, how's about your pension, brother?

• • •

WE HAVE LONG expected the Roosevelt or the Truman Administration's politically-minded "Justice" Department to file a suit against the Sun Oil Company because of the well-known political color of Sun Oil executives.

Now the suit has been filed.

In a statement issued shortly after the suit was filed, President Dunlop of Sun said that he was amazed at the conglomeration of false charges, innuendoes and misleading statements contained in Attorney General McGrath's anti-trust suit against Sun Oil Company and in his accompanying press release.

The only difference between President Dunlop and the writer is that we are not amazed.

We counsel the Sun Oil Company to put up the sort of fight which A&P has put up and which already has McGrath headed back for his hole.

The American public is pretty fair-minded and it appreciates fairness, but, above all, it appreciates guts. We hope that the Sun Oil Company won't take this political suit lying down.

• • •

THE BRITISH are very poor readers of American opinion and action if they cannot see trouble ahead for themselves — through their changing attitude toward the Reds. Aid to England has been sold to the American people by the Truman Administration as something necessary to bolster up still another defense against communism.

Some British complain that one nation cannot buy another nation's policy. There is truth in that, but if funds are provided on the basis of a policy and that policy is changed, no one need be surprised if the funds are withdrawn. If the English government thinks that the American people are providing billions to bolster socialism (and recent utterances of leaders in the English government support this thought), they are due for a bitter disappointment.

Ray L. Dudley

Report from the Observatory

Gasoline Oversupply Only Disturbing

By **RAY L. DUDLEY**, Publisher, and **WARREN L. BAKER**, Editor

THE ONLY DANGER in the industry's current economic picture is the possible threat of an oversupply of gasoline. Recent large additions have boosted these stocks to high levels, and they are due to continue increasing for another two months. Everything else is in good condition, other stocks being at satisfactory volumes for this season of the year. Despite the tempering influence of mild weather in the country's northeast oil heating region, distillate fuel oil inventories are being reduced to year ago levels. Meanwhile, curtailed producing rates have resulted in such heavy drafts, crude oil stocks are low and likely to decline further during February.

The gasoline situation is not yet hopeless, but sharply reduced refinery runs are needed immediately to prevent accumulation of excessive motor fuel stocks. Otherwise, the industry's entire outlook, including that for crude oil, may be endangered. If gasoline stocks continue increasing at recent rates, the industry undoubtedly will face strong downward pressure on prices during following months. Despite its present strong character, even the crude oil price structure probably could not escape a cut if gasoline markets suffer severe reductions.

• • •

THE THREAT of excessive gasoline stocks, pointed out previously in these columns during late months, has become more pronounced because of the rapid growth of these inventories during recent weeks as refiners made the mistake of boosting crude runs to stills. On January 21 stocks of motor fuel had risen to 122-1/3 million barrels, 10½ million barrels above year ago levels and an increase of nearly 15 million barrels during the five weeks since December 17. At this level, inventories were within 6 million barrels of an all-time peak.

Fortunately, for the industry as a whole, so far much of the increase in gasoline stocks has occurred in California. Inventories east of California are only 4 million barrels greater than a year ago, while California stocks are 6 million barrels greater. Hence, reduced refinery runs in February and March could still prevent gasoline from becoming too serious a problem for the industry outside of the West Coast. Recent trends, however, have not been encouraging, as the bulk of recent gains in gasoline stocks has occurred outside California.

As this is the off-consuming season for gasoline, stocks of this product will continue increasing during the next two months. If the rate of growth is the same as has prevailed in recent weeks, motor fuel inventories for the nation as a whole will reach 140 million barrels by the end of March, or 12 million barrels more than the peak of 128 million attained at the close of March, 1949.

• • •

SHARPLY REDUCED RUNS to stills can prevent gasoline stocks from getting too far out of line with consumption requirements. Recent trends offer little encouragement that refiners will make the desired reduction in operations. Already, a wonderful opportunity to improve the position of gasoline and other refined products was passed up when refiners failed to hold down operating schedules during recent weeks. In the four weeks ended January 21, crude runs to stills averaged 5,537,500 barrels daily in contrast with 5,338,500 barrels per day in the preceding four weeks.

High percentage yields of gasoline also have contributed to the increase in motor fuel stocks, but there are no indications that gasoline yields will be adjusted downward during the remainder of the heating oil season.

It is to be hoped that the present high gasoline stock level, together with the approaching end of the heating oil consuming season, will prompt refiners to curtail runs to stills by substantial margins.

• • •

FEBRUARY WILL TELL the story, and the story will be vitally important to the industry's future.

The month of February offers one of the few remaining chances to make corrections in the gasoline

Factor in Industry's Present Outlook

WORLD OIL'S summary of the oil situation at the close of January

situation. In February, 1949, when runs to stills averaged 5,480,000 barrels daily, 10 million barrels were added to motor fuel inventories. If present runs to stills were trimmed by 200,000 barrels daily during the next two months, or to about 5,300,000 barrels per day, gasoline stocks the end of March might be held to a peak of about 130 million barrels.

This would materially brighten the outlook, as increased demand might warrant gasoline inventories going to around 133 million barrels, or 5 million barrels more than the 1949 peak. However, a 12-million barrel gain over last year's volumes, as indicated by recent refining rates, would be entirely too excessive.

• • •

PRICE REDUCTIONS almost certainly would follow any accumulation of gasoline stocks which approach 140 million barrels. This would endanger the crude oil market, as it is doubtful if the refining industry could stand a gasoline price reduction because very low refinery profit margins already exist.

Although recent heavy reductions in crude oil stocks have strengthened this market, a cut in the price of crude oil likely would follow any decline in market postings for motor fuel because this is the only refined product now offering attractive profit margins for refiners.

The direction of the wind was indicated when gasoline prices softened in January under the pressure of growing stocks. Most important development was a reduction of one-half cent a gallon in retail prices in the state of Ohio.

• • •

CRUDE OIL MARKETS have been wonderfully fortified recently by exceptionally heavy drafts on inventories. Although crude probably could not escape a cut if gasoline prices tumble, it is in a position to exert strong resistance to any tendency to reduce market postings.

After declining at the rate of 2 million barrels weekly during the last four weeks, crude oil stocks on January 14 totaled a little less than 250 million barrels. This was nearly 3 million barrels under levels of a year ago, and 25 million barrels under levels existing the end of May, 1949.

Crude stocks are to go lower. When figures are available for the remainder of January, it will be found that additional reductions have occurred. Under producing allowables fixed for February, additional withdrawal of crude from storage tanks should take place even if refiners trim crude runs to stills. Unless refinery runs are cut substantially, the reduction in crude stocks in February will be sizeable, probably dropping these inventories to less than 240 million barrels which would be the lowest volume since early October, 1948.

• • •

PROGRESS HAS BEEN MADE in the distillate and residual fuel oil situation, as well as in crude oil.

Demand for distillate fuel oil has not come up to early predictions due to mild weather in the north and east, but stocks have been declining at satisfactory rates as refiners have held output to reasonable limits. Distillate fuel stocks on January 21 were 69-1/3 million barrels, 5 million barrels greater than a year ago.

Increased demand for residual fuel oil, with coal strikes unquestionably a significant stimulant, has been an encouraging note. Stocks of this product are below year ago levels, totaling 58½ million barrels on January 21 in contrast with 63¾ million barrels at the corresponding season of 1949.

• • •

CALIFORNIA'S SITUATION has improved somewhat, but is still not too favorable.

Production of the West Coast state has been averaging 866,000 barrels per day in recent months against 950,000 barrels daily a year ago.

Shipments of fuel oil to the East Coast have been beneficial. Residual fuel oil stocks have declined from 40 million barrels on October 1 to around 32 million barrels at present. This still leaves California with half of all the residual fuel oil stocks in the nation.

DO YOU KNOW HOW "Metal Petals" BRING YOU SUCCESSFUL CEMENTING RESULTS?

In any cementing where a lower zone must be protected from contamination by the cement slurry (as well as from sloughings or cavings) the Baker METAL PETAL Basket will be found both safe and successful.

The unit is constructed of a number of individual "petals" made of flexible sheet metal. These petals are mounted on reinforcing spring steel ribs, which in turn are mounted on a ring to form the Basket.

When running in the hole, the upward pressure of the fluid tends to close the "petals" thus providing fluid passageway between the Basket and the walls of the hole, without distortion of the Basket. As soon as the casing comes to rest, upward pressure by the fluid is relieved and the petals expand to contact the walls of the hole. Any tendency of fluid to move downward then presses the flexible petals more firmly against the entire circumference of the hole. Solids strained from the fluid tend to build a bridge inside the Basket which is thus converted into a one-way packer of great strength and effectiveness.

SIMPLE, EFFECTIVE ACTION

The "Metal Petals" not only expand to contact the entire circumference of large diameter holes, but also pack-off in holes of irregular shape; and the independent action of the individually mounted overlapping petals permits successful use of the Basket in casing programs with minimum clearances.

All-metal construction and design provide ample strength; lessen the possibility of splitting or otherwise damaging the Basket while it is being run in; and the metals are unaffected by usual acids employed for various purposes.

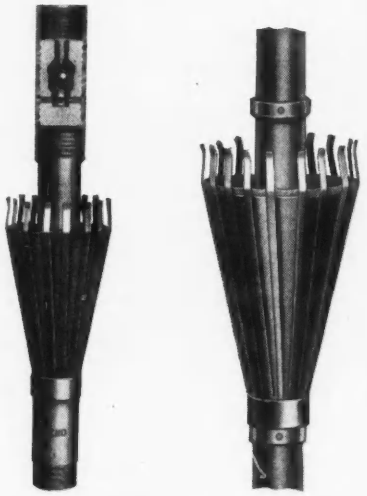
MOUNTINGS TO MEET ALL NEEDS

Baker Metal Petal Baskets are furnished mounted on plain or perforated nipples; with or without different types of Baker Whirler Float Collars; for a wide range of cementing applications. When conditions permit, it is recommended that Baker Metal Petal Baskets be "slidably" mounted to allow rotation, spudding, or reciprocation of the casing without distorting or damaging the Basket. Maximum efficiency of Baskets is assured when a Baker Model "G" Casing Centralizer is used immediately below the Basket assembly. For details see the Baker (or Composite) Catalog; or ask any Baker representative for specific recommendations.

TOP, Baker Metal Petal Basket (Product No. 340) ready for assembly into any required cementing hook-up. The strong, spring steel ribs, each with a "metal petal" attached, expand against the wall of the hole to form a safe "one-way" packer which prevents downward movement of the cement slurry.

LOWER VIEW illustrates the overlapping "petals" (each mounted on its individual spring steel rib) thus providing flexibility and freedom of expansion to pack-off around the circumference of large-diameter holes, or holes of irregular contours. A Baker Model "G" Casing Centralizer mounted just below the Basket is recommended.

LEFT, a popular hook-up consisting of a Baker Metal Petal Basket mounted on nipple, with a Baker Cement Whirler Float Collar with Solid Baffle (Product No. 305) which causes the cement slurry to pass through the baffled, side-whirler ports.



RIGHT. Where the casing is to be rotated or reciprocated while cementing, the Metal Petal Basket is "slidably" mounted between two Stop Rings. This permits free rotation, and ample vertical movement of the casing, without distorting or damaging the Basket.

HERE'S AN EXAMPLE OF STRENGTH

The Baker Metal Petal Basket holds a record for keeping cement ABOVE and OUT OF a "zone" possessing *lower formation pressure* and *higher permeability* than is likely to be encountered in any oil well. The "zone" was an *open* coal mine stope (lateral) through which a 16-inch hole had been drilled. A Baker Metal Petal Basket, mounted on 10¾" casing (used as the surface string) successfully supported a 640-foot column of cement slurry above the stope, without breakdown or leakage. This example not only demonstrates the bridging ability of the Basket assembly, but also is evidence of the tremendous structural strength which it possesses.

BAKER
METAL PETAL BASKET
PRODUCT NO. 340

BAKER OIL TOOLS, INC.
HOUSTON • LOS ANGELES • NEW YORK

The Changing Panorama

Drilling to Stay at 1949 Level

WHILE THE STUDIES involved in WORLD OIL'S annual forecast on U. S. drilling operations for 1950 are even yet in the preliminary stages, it appears from these advance studies that unless prospects improve for increased allowables, drilling in 1950 will be at the same level of 1949 or slightly less.

As has been the custom for many years, letters have been addressed by WORLD OIL to oil companies drilling ten or more wells last year, asking them to give, from their proposed budgets for 1950, the drilling plans for the year. These replies are still coming in in large quantities and it is anticipated that by the time the forecast has been completed, letters will have been received from all companies who drilled 60 percent of last year's wells. At the present time replies have been had from only about 16 percent and the conclusions mentioned in the first paragraph are based upon replies already tabulated.

The complete forecast, by states and areas, will be published in the February 15 issue of WORLD OIL, the Review-Forecast Issue.

The questionnaire returns from the oil companies constitute only one of many considerations involved in the forecast.

As it now appears, the editorial committee assisting the Publisher of WORLD OIL in the forecast is of the opinion that drastic reductions (more drastic than are in any way probable) in imports could increase the number of wells to be drilled in 1950 by as much as 7 to 10 percent, involving expenditures of as much as 125 million dollars for drilling and equipping producing wells. Such a drastic reduction could easily put several hundred million dollars into the pockets of American oil operators during the year, thus making it possible and necessary for the increased drilling campaign.

Whether or not it would be good economics for the domestic industry to go ahead with an *expanded* drilling campaign is subject to some doubt. Some economists say that the addition of a few thousand more wells at this time, in the face of a foreign market threat, would be unsound. Independent operators say that such an increase in domestic reserves and potential producing capacity is no more foolish than the admission of increased hundreds of millions of barrels of foreign oil. Already two major companies have announced, since the beginning of the year, a decrease in anticipated foreign imports.

Fully cognizant of the need of various American companies to withdraw quickly as much of their foreign oil as possible, we still think that American oil producers abroad are playing with fire when they import oil in such quantities as to cause important oil-producing states to face tremendous reductions in state tax income. The only reason reprisals have not been made against such companies is that no satisfactory legal way has been figured out yet.

Never in the entire history of our forecasting, save in 1942 and 1947, did oil companies depart so completely from announced plans as was the case in 1949! Thus far, a study of the deviation of the individual company from its original budget is most confusing. Some major companies cut their 1949 drilling plans by tremendous percentages—some by almost half. Others increased by unbelievable percentages. The same thing applied to the smaller companies. Here the effect of successful wildcatting, as always, had a pronounced effect. The only pattern which seems to develop from the study is the effect of lowered allowables, the effect of such price cuts as were made, and the fear of further cuts.

That these fears still exist is apparent in the plans for 1950 and in letters accompanying the replies to our questions as to wells to be drilled.

Better Record Shows Safety Efforts Pay

EFFORTS OF THE OIL INDUSTRY in promoting safety are paying big dividends. This is evidenced by figures released by the Bureau of Mines which show that the industry in this country improved its safety record appreciably during 1948, the last period during which complete statistics have been compiled.

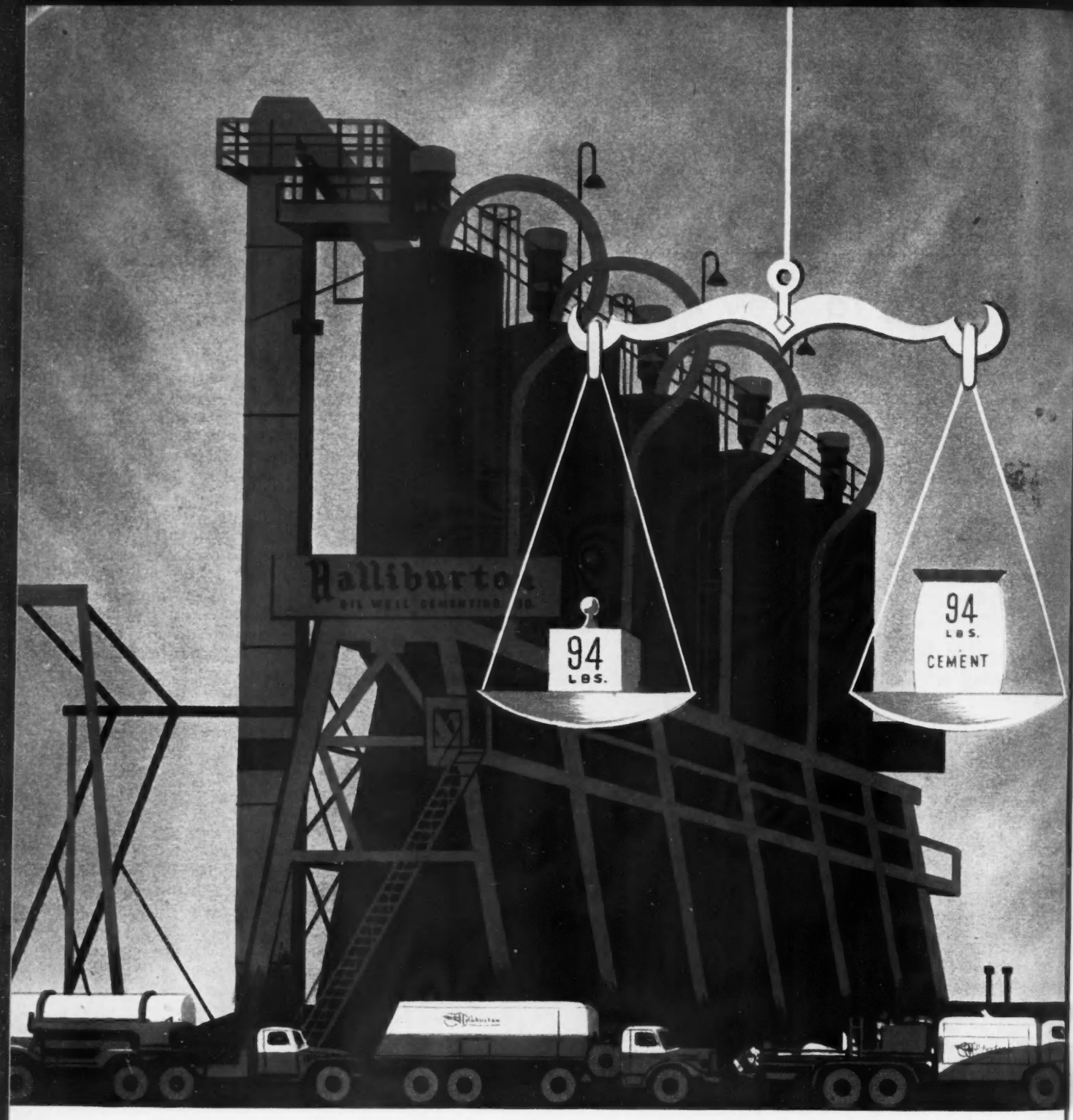
An injury-frequency of 14.46 per million man-hours and an injury-severity of 1.46 days of disability per thousand man-hours, reflected an improved safety record for the industry, shows the effectiveness of properly organized and conducted safety campaigns, according to the Bureau of Mines study conducted by Joseph H. Schuster and G. W. Crone, Accident Analysis branch, Economics and Statistics division of the Bureau. The frequency rate for 1948 was the lowest since 1942 and the severity rate was the lowest attained by the industry since the Bureau started compiling injury statistics for the country seven years ago.

Only appreciable increase in injury frequency was in the drilling branch, the most hazardous. There, the frequency rate in 1948 was 72.73 injuries per million man-hours and the severity rate was 7.94 days of disability per thousand man-hours, compared with 65.46 and 6.14, respectively, for 1947. Both of these rates were more than five times higher than the corresponding average rates for the industry.

It is obvious that oil operators and drilling contractors should give greater attention to safety programs in the drilling branch of the industry in order for this department to get into line with the trend towards fewer accidents. A better showing would certainly be reflected in lower insurance rates which contractors declare are too high at the present time.

Exploration, production and marine transportation, both inland and ocean, likewise had frequency and severity rates higher than the average rates for the industry as a whole. The frequency rate of 19.87 per million man-hours for exploration was slightly higher than the corresponding rate in 1947, and the severity rate of 2.19 compared with the rate of 0.64 in 1947. Production had fairly favorable injury experience in 1948 and an improvement was also noted in the safety record of inland and ocean marine transportation.

Compared with other departments, the safety records of refining and marketing were extremely favorable and for the fourth consecutive year the frequency rate for refining was lower than the rate for the preceding year.



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There is no substitute for experience in oil well cementing

HALLIBURTON OIL WELL CEMENTING COMPANY

DUNCAN, OKLAHOMA

Monthly News Analysis

Imports Reduction Likely as Lawmakers Prepare for Action

Help at Last?

LIKE the little Dutch boy who stuck his finger in the dike and howled for help, U. S. independents began to think they might breathe a long sigh of relief last month as the relief party came pounding up the halls of Congress.

The long-time demands of U. S. independents for a dam against the swelling stream of oil imports were being echoed in high places and there was likelihood of imminent action in the form of tariff, quotas, or voluntary cuts.

Relief was still in the talking stage—necessary prelude to action under the democratic system—but so many of the "right" people were parroting or paralleling the independents' arguments that there could be little doubt that the voice in the wilderness had become a chorus to be heard and heeded.

Some of the echoes: Rep Gossett (D., Texas): ". . . Now we are faced with a situation where domestic labor is being forced into idleness. Refineries are being closed. Independents in the industry are going broke. . . . Importation of foreign oil will soon rise to a million barrels per day or more."

Rep. Lucas (D., Texas): ". . . they (the independents) are not continuing their exploration of the oil fields, and they are fast going into the hands of the large producers, creating a greater and greater monopoly in the oil production."

Oil Workers International Union: "Our 1950 program must encompass well planned efforts to resist this unnecessary and destructive foreign competition."

Commerce Secretary Sawyer: "An exception to the otherwise satisfactory picture given me on conditions in Texas and Oklahoma concerned a falling off in domestic crude oil production and in employment . . . A number of independent oil producers, representatives of firms doing drilling or selling supplies and equipment in the oil fields, as well as union officials, ascribed the situation to the high level of crude oil imports . . ."

President Truman: ". . . we must provide aids to independent business so that it may have the credit and capital to compete in a system of free enterprise."

He followed this statement, from his State of the Union message, by giving audience to Rep. Albert Thomas of Texas, who complained of imports' threat to U. S. oil. Thomas disclosed that the President agreed to restrict oil imports if a survey by Interior Secretary Oscar Chapman showed that they were injuring the domestic industry. (With imports now nearly 800,000 barrels daily, the Chapman recommendation is likely to propose limitations.)

What form the limitation would take was problematical, but there was a growing chance in late January that it might be voluntary. In what appeared to be the first break in the ranks of the importers, The Texas Company announced that, effective February 1, it is reducing its imports of foreign oil by 14,275 barrels per day below scheduled levels. Standard Oil Company (N. J.) followed closely with the announcement that it will reduce imports from 13,000 to 15,000 barrels daily during the next 5 months.

If other importers followed the lead, there was certain to be a lessening of pressure on Congress for the enactment of legislation compelling imports reductions, and might result in a system of self-imposed quotas.

(W. S. S. Rogers, Texaco's chairman of the board, added the prudent warning that "This downward revision of our forecast may of course be affected by the following: (1) an unfavorable settlement of the British sterling-dollar controversy; (2) a continuation of the coal dispute which would make it necessary for us to bring in more foreign crude or fuel oil to satisfy the needs of our customers; and (3) a situation where the company is suffering drainage in fields where we are not the sole operator.")

If restrictive legislation is imposed, it might approximate one of these proposals:

- Rep. Gossett introduced a bill to boost the excise tax on crude oil imports from 10.5 cents to $1.05 per barrel. He would also increase the tariff on lube oils to 4 cents per gallon and on petroleum wax and paraffin to 1 cent per pound. Gossett said the bill would develop a revenue of more than $300 million a year.
- Chairman Wright Patman of the House Small Business Committee, who has said that the importing companies plan to boost their imports of crude and products by 56 percent in the first half of 1950 over levels of the corresponding period last year, has unofficially offered three suggestions to curb petroleum imports: (1) Legislation requiring that for every barrel of imported oil, the importer would have his domestic production reduced by one barrel. (2) Legislation limiting the quantity of oil imported to the total quantity exported. (3) Invocation by the President of the escape clause in the existing trade agreements to impose duties and quotas to limit imports to "reasonable levels."

As indicated by Rogers, the whole

problem may hinge on a compromise of the British oil-dollar dilemma.

Since the British announced they would cut fuel oil imports into the sterling area to virtually nothing, and gasoline imports to a third of current levels, a storm of protest has swept to London from both American government and industry sources. An indication that this objection may be effective is seen in London's modification of the curb from January 1 to February 15. The British announced that they have postponed the time of restricting imports in order to study the matter, but some American observers believe the real reason is that Britain is as yet in no position to supply its oil needs from sterling sources, either in the Middle East or in Venezuela.

The Oil and Gas division of the Department of Interior went to work drafting a bitter protest to the British restriction, and it is understood that Interior Secretary Oscar Chapman "has been impressed with the argument." The State Department also has objected to London, and British Minister of Fuels and Power Victor Butler flew hurriedly back to London with the document.

The compromise which it is understood is favored by the U. S. government would allow American companies to sell petroleum products for sterling in the sterling area. This, it is argued, would not constitute a drain on Britain's slim dollar resources, the expressed reason for the limitation policy. Many American companies are believed ready to operate in the sterling area on a sterling basis, either accepting sterling payments in escrow in England, or oranizing British subsidiaries to carry on their activities. Either of these two plans would prevent the loss of world oil markets to the Americans and would hold positions until some currency convertibility program could be worked out.

However, if American firms set up British subsidiaries, the tax burden would be about 50 percent of profits, and some industry economists fear this would require American companies in such areas as the Middle East to operate solely on a cost basis.

Meanwhile, officials of the Economic Cooperation Administration are extremely anxious as to the fate of ECA funds for Britain. The House Small Business Committee declares it will demand that ECA review its program in financing British refinery expansion with the aid of American taxpayers' dollars. ECA itself has disclosed that it will withhold all further grants to Britain until that country "clarifies" its intentions as to American petroleum imports.

Super-Salesman at Work

That John L. Lewis is becoming the oil industry's best salesman is told in recent news accounts of substantial industrial and industrial conversions from coal to oil. Union Pacific Railroad has announced intention to convert 35 to 40 locomotives from coal to oil due to inability to obtain a steady supply of coal from Wyoming coal mining properties. In residential construction, figures show that for the first nine months of last year, installations of coal-fired furnaces in the U. S. were off 45 percent, while oil burners increased 9 percent and gas types increased 41 percent. Numerous builders report that they now seldom install coal-fired heating equipment in new construction.

Sun Refutes Federal Charges Of Anti-Trust Violation

The jaws of the Justice Department snapped shut in another anti-trust suit last month—but they may have bitten into a buzz-saw.

It took Robert G. Dunlop, articulate and aggressive president of Sun Oil Company, less than 24 hours to regain his breath and issue a roaring, categorical denial of the government's charges.

Charged the government: Sun coerced service station dealers by compelling them to enter into and comply with so-called exclusive dealing contracts.

Said Dunlop: We have no such contracts.

The charge: Sun has "foreclosed to competition" the 18-state market where it has retail outlets.

The reply: "Ridiculous!" Even Attorney General McGrath, said Dunlop, admits in the complaint against Sun that the company has no more than 8.5 percent of gasoline business in that area.

The charge: Sun has about 10,000 dealers.

The reply: Sun operates only 43 service stations itself, as compared with 6550 individually operated stations directly supplied by Sun.

The charge: Sun requires dealers to handle only auto accessories distributed by Sun.

The reply: Sun has repeatedly made clear to dealers that it sold such acessories on a "competitive quality, price and delivery basis" and that "dealers are free to purchase or reject all or any part of such lines of products. As a matter of fact, most of these dealers do handle lines of automotive accessories supplied to them by others."

Dunlop concluded by saying Sun seeks an early trial to present the truth and refute these unjust accusations.

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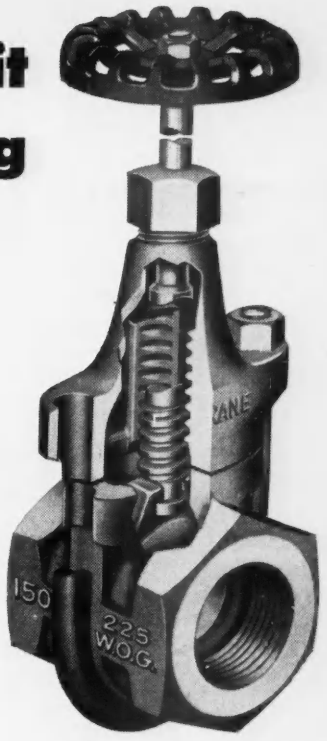

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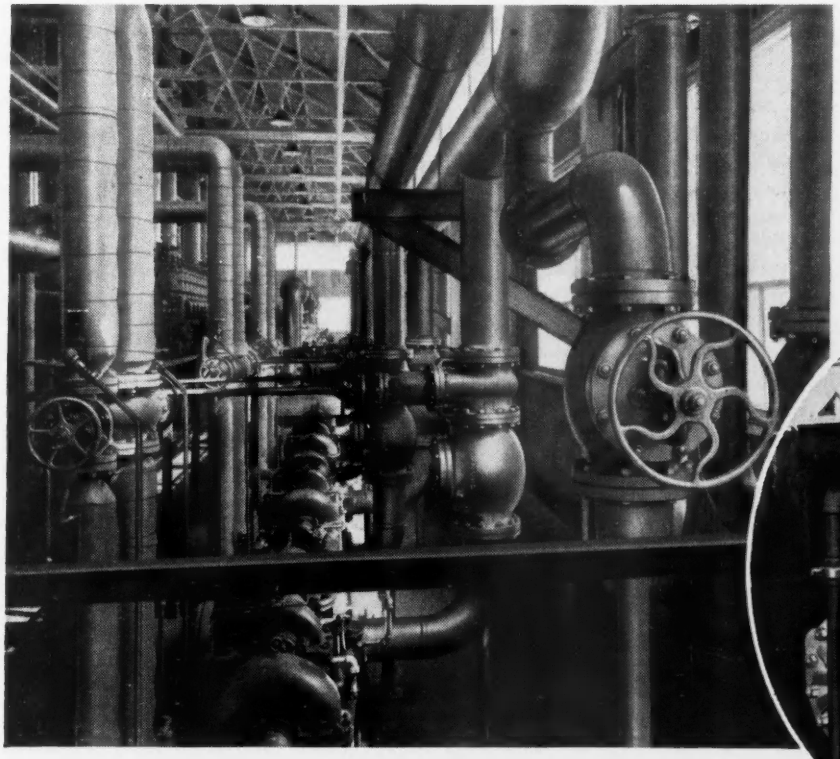

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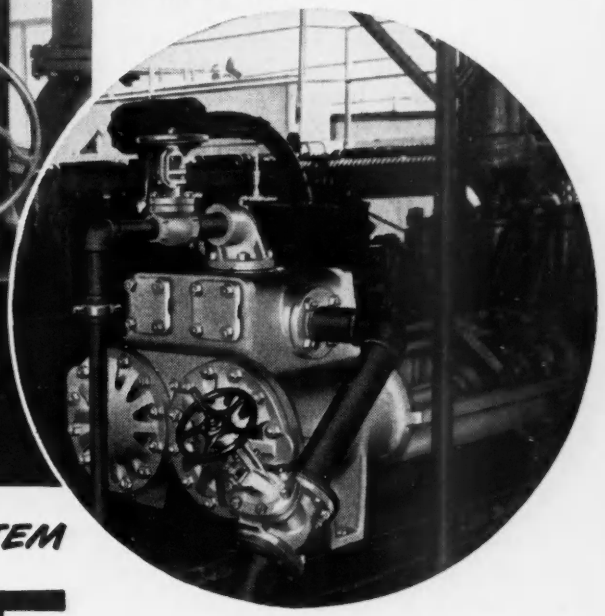

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Reversed Stand on Depletion Will Bring Strong Opposition

Harry Truman, Rep. Albert Thomas of Texas, and the U. S. oil industry had reason to feel last month that the President's speech writers ought to give him advance notice of what he's going to say.

After a chat with the President on Jan. 13, Rep. Thomas quoted the chief executive as saying he had no intention of altering the oil industry's depletion allowance.

Ten days later Mr. Truman tabbed the allowance "a shocking example of how present tax loopholes permit a few to gain enormous wealth without paying their fair share of taxes." He made it plain that the allowance would be reduced under a revised tax structure that aims to bleed $1 billion a year in new revenues.

Coming from Mr. Truman, the dirge was new, but the words had a familiar, sour taste to those in the oil industry whose memories stretched back to 1942, when Treasury Secretary Morgenthau attacked the depletion allowance and got his come-uppance.

The President termed the allowance "an exemption" which "goes on and on, year after year, even though the original investment in the property has already been recovered tax free, not once but many times over."

Coupled with present "preferential provision which permits oil well investment costs to be immediately deducted from income regardless of source," depletion allowance is allowing "vast fortunes" to be built up with only token tax payments, charged Mr. Truman.

The President's recommendation was greeted with roars that sounded like more than Congressmen's lip service to their constituents. Here was a boot that trod on every toe in the oil industry—majors, independents, labor and landowners—and the mining industry as well. Political heads have rolled into the slush pits for less, and the legislators were acting like men who realized it.

First big hurdle the Truman proposal faces is the House Ways and Means Committee, which must write whatever tax legislation is reported to the House. More than half of this group are from states which have oil or mining.

If the recommendation runs the Committee gantlet, it exposes its backside to a paddling on the floor of the House. Speaker Sam Rayburn of Texas (whose constituency is oil-soaked) was quick to reiterate his stand that there should be no change in the allowance. Rep. Thomas of Houston said: "If they want to break the little fellow, there's no better way to do it."

Thomas' argument was substantially the same as that which killed Morgenthau's proposed changes in 1942, when the Secretary charged that the government was losing $80 million a year in revenue because of "special privileges" extended to the oil and gas industries. The committee killed the proposed changes after being told that if the depletion allowance were eliminated "risk capital" for new exploration would be curtailed and thousands of stripper wells would be plugged.

Oil men are saying that this is even more true now than in 1942. Not only is the risk of finding a producing well or field greater, but costs are up.

Best guess is that the Treasury wants a 15 percent depletion allowance for oil and gas instead of the present 27½ to 50 percent. Of the remaining industries affected, coal is allowed 5 percent, sulfur 23 percent, and the others 15 percent.

Outlook More Favorable For Demand in 1950, Says Bureau

The U. S. Bureau of Mines had a worried eye on the weather last month as it predicted a reversal in 1950 of 1949's drop in total demand on the U. S. for crude and all petroleum products.

The Bureau forecast that total domestic and export demand on the U. S. for all oils will average 6,315,000 barrels per day in 1950, compared with 6,118,000 in 1949, an increase of 3.2 percent. Then it took a long look at the factors that held 1949 demand below 1948.

Chief among these was "abnormally mild weather in the first and last quarters of 1949 (which) retarded the growth in the domestic demand for heating oils."

Other reasons for the drop: Growth of crude oil supply and refinery capacity abroad plus the problem of dollar exchange have created a sharp downward trend in exports since 1947, and the consumption of residual fuel oil by railroad locomotives has been reduced one-third in the last two years.

The Bureau's total estimated 1950 forecast includes domestic demand of 6,046,000 barrels per day, plus exports of 269,000 barrels per day.

Demand for domestic crude is figured at 5,129,000 barrels per day, compared with 5,054,000 for last year.

Imports for this year are estimated at 704,000 barrels per day, against an estimated rate of 640,000 barrels daily for last year—an increase of 64,000.

Domestic demand for products in 1950, as estimated by the Bureau, includes (in millions of barrels): Motor fuel, 952; residual, 478; distillate, 367; kerosine, 112; all other, 289.

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Supreme Court Ruling Creates Extended Authority for FPC

The Federal Power Commission last month gained a Supreme Court victory that was all out of proportion to its surface importance.

By a five-to-two vote, the high court decided that the regulatory authority of the FPC covers a natural gas transmission company whose lines are entirely within one state.

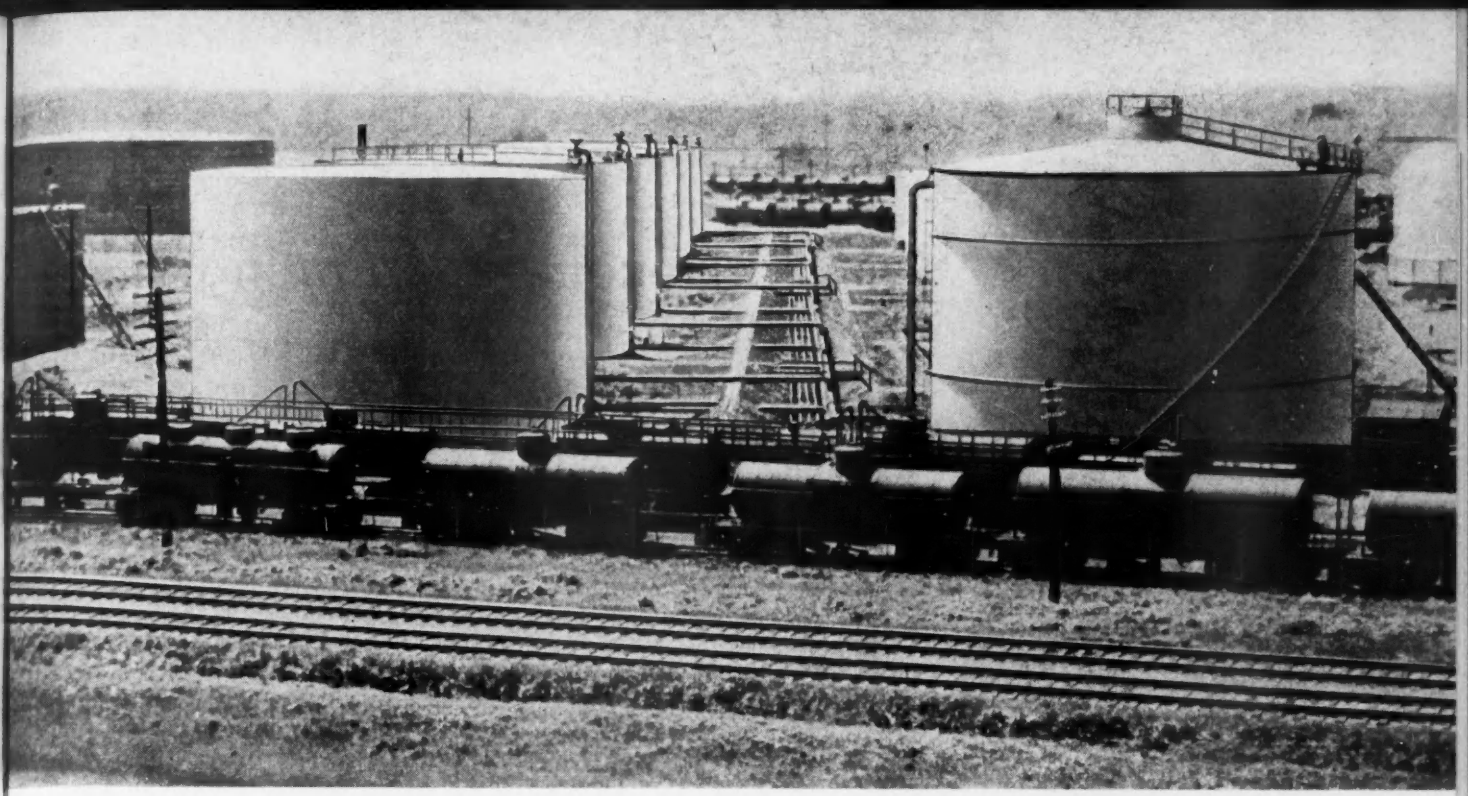
A lower court had previously ruled that the FPC could not exercise certain controls over the East Ohio Company, a corporation which operates 650 miles of transmission lines within the state of Ohio.

Significance of the case is that more than 40 similar cases are pending. FPC has already held several other companies, whose pipe lines are in one state, to be "natural gas companies" within the meaning of the Federal Power Act, and therefore to be under FPC control.

The court's ruling does not give FPC authority to regulate rates that may be charged for gas in such cases. The states continue to have that authority. But it does mean that East Ohio—and other such firms—must have FPC certificates of necessity, must comply with the commission's cost and accounting procedures, and would be subject to FPC controls over abandonments, construction, and extension of facilities and procedures to eliminate inflationary writeups. This pertains only to East Ohio's transmission functions and not to the local retail distribution system.

In rejecting the company's contention that its 650-mile pipe line system is incidental to local distribution, the court's majority held that "What Congress must have meant by facilities for 'local distribution' was equipment for distributing gas among consumers within a particular local community, not the high-pressure pipe lines transporting the gas to the local mains."

The dissenting justices declared that it is obvious that "intrastate transmission lines of a retail gas company, devoted exclusively to serving communities within the state, are facilities used in the local distribution of natural gas and are accordingly exempted from the application of the act."



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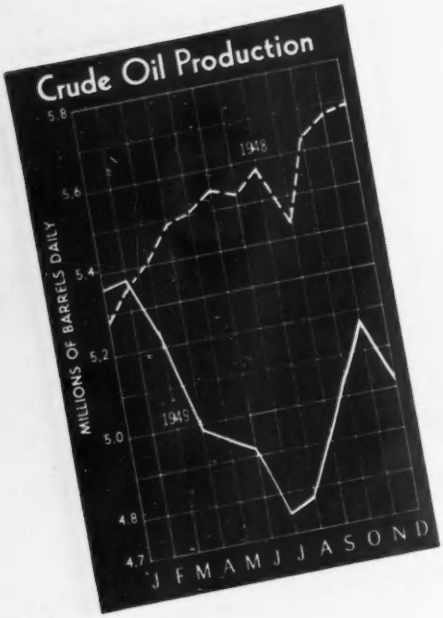
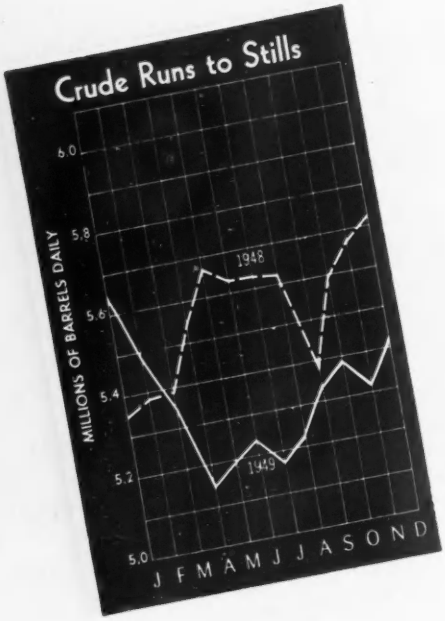
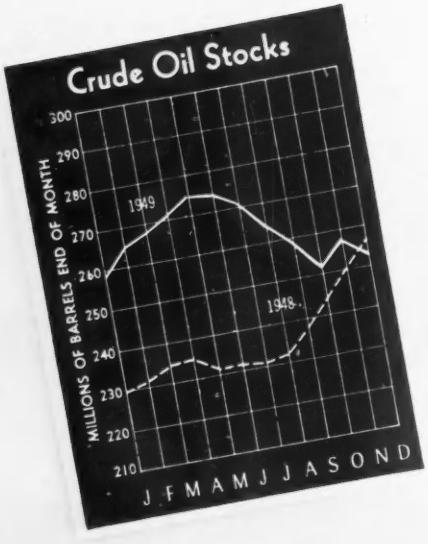






December Refining Hike

By CECIL W. SMITH,

THE combination of lower crude production and higher refinery activity during December canceled about one-half the gain in crude stocks made in November due to a production hike and a refining drop. Although stepped-up refining in December improved the crude stocks position, it had the opposite effect on gasoline stocks.

Had it been possible to hold gasoline production to the consumption level, thereby adding little or none to storage during December, motor fuel stocks would have ended the year at about the same level they were a year before and would be in far better position. A cut was made in gasoline output during the month, but still stocks climbed more than 8 million barrels to a point almost 10 million more than were in tanks a year earlier.

December's colder weather started heating oils moving out of storage and by the end of the month, light distillate fuels were closer to the end of 1948 level and the heavier residuals had dipped below previous year's inventory.

In order to halt the climb in crude stocks that started in November, production was cut 170,000 barrels a day in December, dropping the daily average to 5,004,000 barrels. In the same month of 1948 daily output amounted to 5,688,000 barrels, or 684,000 barrels more than was produced in December. As in the past the drop in the nation's production had to occur in Texas.

Texas' wells were held back from 2,178,500 barrels a day in November to 2,014,800 in December, which was a drop of 163,700 barrels daily and almost all of the nation's decline. A year before, Texas had produced 538,000 barrels a day more than it did in December.

Refineries processed 5,422,000 barrels of crude a day during the month, while the rate had been 5,271,000 in November, a gain of 151,000 a day. While refining rates were below those of 1948, they were not as much under as was crude production. Refinery runs at the end of 1949 were only 298,000 a day less than runs at the end of 1948, while crude output was 684,000 a day less.

Crude Oil and Refined Products Trends

(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month
1948:									
January	5,283	5,348	229,842	2,328	102,167	1,082	39,788	1,278	36,260
February	5,353	5,380	231,419	2,264	110,999	1,127	33,019	1,295	35,602
March	5,406	5,387	234,164	2,252	111,949	1,050	30,570	1,307	34,192
April	5,484	5,540	234,506	2,396	109,289	978	32,564	1,303	35,527
May	5,502	5,668	231,318	2,486	108,552	992	38,551	1,314	41,123
June	5,544	5,632	231,412	2,529	104,518	998	45,835	1,280	44,213
July	5,522	5,631	230,955	2,494	98,839	994	56,045	1,264	49,448
August	5,577	5,621	231,954	2,532	95,445	1,038	65,887	1,248	55,009
September	5,435	5,376	237,302	2,416	90,518	961	73,854	1,154	58,682
October	5,632	5,594	243,972	2,490	92,426	1,069	79,992	1,268	61,456
November	5,675	5,672	250,066	2,551	95,589	1,081	80,658	1,277	64,865
December	5,688	5,720	256,254	2,626	103,697	1,106	71,475	1,299	64,021
1949:									
January	5,365	5,641	258,648	2,538	116,621	1,063	61,584	1,348	62,508
February	5,376	5,480	265,216	2,484	126,054	1,004	53,937	1,282	59,398
March	5,224	5,352	269,341	2,470	127,443	993	48,923	1,258	58,190
April	5,012	5,141	272,520	2,494	125,351	846	51,231	1,147	59,668
May	4,972	5,195	273,912	2,585	121,602	813	57,442	1,138	63,576
June	4,903	5,162	274,691	2,597	114,041	771	64,730	1,041	64,628
July	4,704	5,173	267,586	2,613	111,217	835	71,553	1,040	66,084
August	4,780	5,241	260,585	2,593	104,879	902	76,037	1,078	66,843
September	4,940	5,427	251,689	2,617	101,799	1,002	83,213	1,110	67,117
October	5,029	5,373	250,932	2,643	103,287	1,001	90,643	1,141	68,673
November	5,174	5,271	257,598	2,586	105,115	998	90,454	1,147	66,621
December	5,004	5,422	254,449	2,400	113,497	1,036	77,801	1,211	61,675
Dec., 1949 Change:									
In Month	—170	+151	—3,149	—186	+8,382	+38	—12,653	+64	—4,946
In Year	—684	—298	—1,805	—226	+9,800	—70	+6,326	—88	—2,346

Trends in U. S.

Improves Crude Stocks

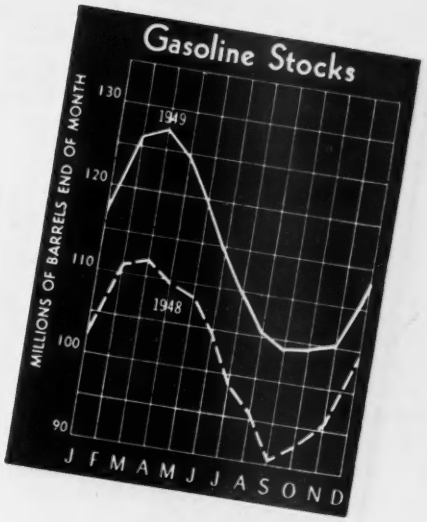
Statistical Editor

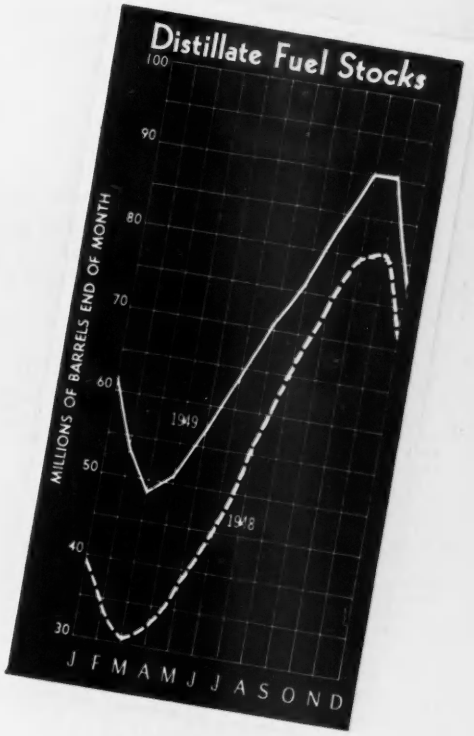
A drop of 3,149,000 barrels in crude stocks that developed from lowered production and increased refining, moved the crude stocks total down to 254,449,000 barrels. That was still higher than the 250 million-barrel level that is now generally accepted as the desirable working level, but November had seen inventories jump to 257,598,000 barrels and this reduction was a good start toward normalcy. Lower crude production and higher refining rates in January would result in further lowering of crude stocks.

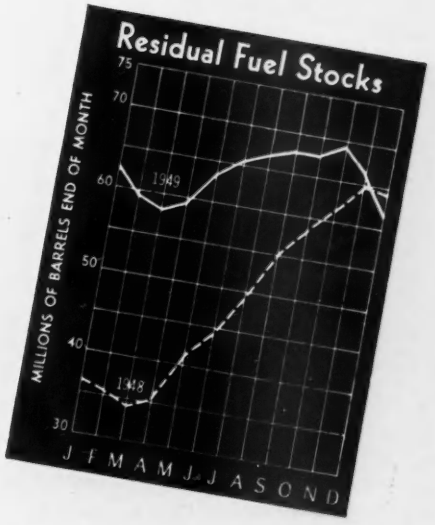
Stocks of finished and unfinished gasoline gained 8,382,000 barrels during December and boosted the nation's total to 113,497,000 barrels. That was 9,800,000 barrels more than were in storage at the end of 1948, and those stocks went on to total an excessive 127,500,000 barrels. If gasoline is produced and accumulated in the next three or four months at the early 1949 rates, the inevitable softening of gasoline prices would probably cause crude prices to seek lower ground.

Distillate fuel oil stocks were lowered 12,653,000 barrels during the month to end totaling 77,801,000 barrels. That was still 6,326,000 barrels more than were in storage a year before, but it was considerable improvement over the position held at the end of November when there were 9,526,000 barrels more than a year before.

Withdrawals totaling 4,946,000 barrels were made from residual stocks in the month and lowered the nation's total to 61,675,000 barrels. That total was 2,346,000 barrels less than was held a year before, making residual the only major refined product with stocks in that position.







State Crude Oil Production

(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION				TOTAL YEAR		
	Dec., 1949	Nov., 1949	Dec., 1948	% Diff. Dec. '48-'49	1949	1948	% Diff. '48-'49
Alabama	1.5	1.3	1.2	+ 25.0	456	466	— 2.1
Arkansas	78.7	77.8	86.7	— 9.2	29,521	31,675	— 6.8
California	868.8	868.3	949.6	— 8.5	332,749	340,089	— 2.2
Colorado	62.0	64.1	42.7	+ 45.2	24,014	16,827	+ 42.7
Florida	0.9	1.0	0.8	+ 12.5	440	290	+ 51.7
Illinois	178.8	181.4	177.7	+ 0.6	64,652	64,669	.....
Indiana	28.2	28.5	22.5	+ 25.3	9,501	6,710	+ 41.6
Kansas	284.2	284.5	314.5	— 9.6	101,894	110,833	— 8.1
Kentucky	25.3	24.9	23.3	+ 8.6	8,621	8,551	+ 0.8
Louisiana	558.5	551.7	520.8	+ 7.2	190,942	181,181	+ 5.4
North Louisiana	129.6	125.6	125.1	+ 3.6	44,727	43,468	+ 2.9
South Louisiana	428.9	426.1	395.7	+ 8.4	146,215	137,713	+ 6.2
Michigan	44.5	44.6	48.5	— 8.2	16,378	16,870	— 2.9
Mississippi	100.8	99.1	127.6	— 21.0	37,999	45,809	— 17.0
Missouri	0.1	0.1	0.2	— 50.0	48	53	— 9.4
Montana	22.9	24.1	25.8	— 11.2	9,154	9,380	— 2.4
Nebraska	1.4	1.2	0.8	+ 75 0	318	240	+ 32.5
New Mexico	130.3	131.0	136.5	— 4.5	47,893	47,969	— 0.2
New York	13.4	13.3	12.4	+ 8.1	4,385	4,621	— 5.1
Ohio	9.1	9.0	9.1	.....	3,426	3,300	+ 3.8
Oklahoma	409.6	425.4	450.2	— 9.0	151,139	154,032	— 1.9
Pennsylvania	27.6	26.9	32.9	— 16.1	11,237	12,667	— 11.3
Tennessee	0.1	.....	.....	.....	22	8	+175.0
Texas	2,014.8	2,178.5	2,552.8	— 21.1	744,766	903,318	— 17.6
Dist. 1—South Central	26.1	27.3	28.0	— 6.8	9,693	10,036	— 3.4
Dist. 2—Middle Gulf	119.5	113.1	181.1	— 34.0	47,559	64,349	— 26.1
Dist. 3—Upper Gulf	387.1	415.8	516.5	— 25.1	145,208	183,374	— 20.8
Dist. 4—Lower Gulf-S.W.	189.5	205.3	252.7	— 25.0	71,987	92,958	— 22.6
Dist. 5—East Central	34.3	37.5	51.9	— 33.9	13,561	17,496	— 22.5
Dist. 6—Northeast	326.2	366.0	418.6	— 22.1	127,680	157,034	— 18.7
Dist. 7-B—N. Central	61.5	63.1	62.1	— 1.0	22,152	18,299	+ 21.1
Dist. 7 C—West Central	51.3	54.9	50.3	+ 2.0	17,175	16,622	+ 3.3
Dist. 8—West	586.2	639.6	741.7	— 21.0	210,669	255,412	— 17.5
Dist. 9—North	140.7	143.6	144.3	— 2.5	49,392	51,326	— 3.8
Dist. 10—Panhandle	92.4	92.3	89.1	+ 3.7	33,255	31,869	+ 4.3
Utah	2.9	2.5	.....	.....	464	.....	.....
Virginia	0.1	0.1	0.1	.....	42	33	+ 27.3
West Virginia	7.8	8.0	7.1	+ 9.9	2,830	2,687	+ 5.3
Wyoming	131.2	126.6	144.2	— 9.0	46,724	54,004	— 13.5
Total United States	5,003.5	5,173.9	5,688.0	— 12.0	1,839,615	2,016,282	— 8.8

Completions

Fall Below 1948 Record

THERE were 38,518 new wells drilled in the U. S. during 1949 to make the year the second most active in history. Second only to 1948 when the all-time high of 39,477 new wells were completed. The totals show that 1949 failed to equal the top year by 2.4 percent.

Even though 1949 failed to match the 1948 well record, it did better the amount of footage drilled and reached a new high in that department. The previous footage record had been set in 1948 along with the record wells, but 1949 with fewer wells topped that mark by almost one million feet.

Total footage recorded in 1949 amounted to 137,999,453 feet, which included footage drilled in new wells and new footage added to old wells. A year before the comparable total had been 137,103,025. Considering only new well operations, the 1949 average depth per well amounted to 3573 feet each, for a new all-time high. In 1948, new wells were only 3463 feet deep on the average.

Well completion totals mentioned above were for new wells only and did not include the number of old wells that were deepened. The over-all drilling operations completed in 1949 totaled 38,999, while a year earlier they amounted to 40,010. The deepening projects amounted to 481 in 1949 and 533 in 1948.

Generally it can be said that the national drilling trend will closely follow that of Texas, but in the year just past that was not true. Texas added about 1500 wells, or 12 percent, more to the nation's total than it did in 1948, while the U. S. as a whole was down slightly more than 2 percent. The main offset to Texas' gain occurred in the Appalachian Region where lessened demand and lower prices for Pennsylvania grade crude resulted in a reduction of about 40 percent in drilling.

Other principal drilling states that had declines during the year were California, Kentucky, Mississippi, New Mexico, Ohio, Colorado, and Montana.

Partly offsetting those losses were gains in Arkansas, Illinois, Indiana, Louisiana, Michigan, Oklahoma, and Wyoming.

Well Completions in the United States during December, 1949, and Cumulative for Year

(Figures compiled by WORLD OIL Staff from private reports and other sources as follows: Illinois from Illinois Geological Survey; Indiana from Indiana Division of Geology; Missouri from Missouri Geological Survey; Tennessee from Tennessee Division of Geology; Bradford, Kane-Clarendon and Allegany fields of Pennsylvania and New York from The Producers Monthly)

STATE or DISTRICT	MONTHLY COMPLETIONS, DECEMBER, 1949									TOTAL COMPLETIONS				CUMULATIVE TOTAL				Rigs in Operation (Drilling, Rigging Up and Shut Down)		
	NEW WELLS																			
	Oil	Dist.	Gas	Dry	Water Input	Gas Input	Water Disposal	Total New	Total Drilled Deeper	Dec., 1949	Nov., 1949	Dec., 1948	Footage December, 1949	Wells 1949	Wells 1948	Percent Diff.	Footage 1949	Dec. 31, 1949	Nov. 30, 1949	Dec. 31, 1948
Alabama	1			3				4		4	1	2	16,643	19	21	— 9.5	88,654	2	4	4
Arizona														5	4	+ 25.0	15,603	3	4	8
Arkansas	12		1	18				31		31	31	24	90,473	336	322	+ 4.3	1,303,935	25	26	37
California	107		3	38				148	2	150	212	204	585,833	2,485	2,626	— 5.4	9,919,185	206	227	259
Colorado	1		1	6				8		8	5	20	28,495	70	212	— 67.0	305,355	14	17	25
Florida				1				1		1	1	3	11,519	18	28	— 35.7	125,743	4	4	5
Georgia														4	3	+ 33.3	12,437	1	1	
Illinois	132		2	163				297		297	242	235	595,928	2,719	2,491	+ 9.2	6,313,421	234	255	263
Indiana	35		2	49				86		86	104	104	176,199	1,220	1,101	+ 10.8	2,266,148	138	143	119
Kansas	109		33	95			5	242		242	337	336	795,938	3,082	3,069	+ 0.4	10,164,640	302	303	320
Kentucky	29		23	22				74		74	102	58	147,087	950	1,056	— 10.0	1,757,517	86	93	76
Louisiana	141	12	16	73			1	243	1	244	215	175	1,229,747	2,342	2,252	+ 4.0	12,504,218	236	241	205
North Louisiana	98	6	13	45			1	163	1	164	141	114	558,367	1,434	1,478	— 3.0	4,654,779	75	82	61
South Louisiana	43	6	3	28				80		80	74	61	671,380	908	774	+ 17.3	7,849,439	161	159	144
Maryland														1	1		4,900			
Michigan	25			26				51		51	81	90	120,376	902	764	+ 18.1	2,068,339	135	140	109
Mississippi	9	2	1	14				26		26	18	30	180,985	337	429	— 21.4	2,454,063	34	38	37
Missouri	1		1	4				6		6	4	2	4,829	32	53	— 39.6	17,078	7	10	10
Montana	3			4				7		7	26	16	25,330	251	305	— 17.7	626,520	35	43	53
Nebraska				1				1		1	3		4,325	15	9	+ 66.7	64,272	7	6	
Nevada															1	—100.0				
New Jersey															1	—100.0				
New Mexico	24		4	9				37		37	44	69	156,590	517	623	— 17.0	2,254,904	95	103	104
New York	49		1		30			80		80	97	144	113,012	936	1,781	— 47.4	1,336,320	105	95	179
North Carolina																				
North Dakota				1				1		1	1		8,435	5	2	+150.0	26,465		1	1
Ohio	24		27	28				79	1	80	98	78	152,027	1,048	1,324	— 20.8	2,207,198	152	169	203
Oklahoma	204		10	118	2		2	336	9	345	480	329	1,235,616	4,411	4,151	+ 6.3	15,624,655	540	545	501
Pennsylvania	43		28	11	32	10		124		124	169	242	233,946	1,975	3,306	— 40.3	3,584,740	245	248	391
South Dakota														6	3		12,803	2	2	2
Tennessee												5		27	67	— 59.7	27,001	7	7	9
Texas	767	10	58	342		2	1	1,180	17	1,197	1,268	1,229	4,939,283	14,112	12,596	+ 12.0	58,316,093	1,398	1,384	1,492
Dist. 1—S. Central	20		1	29				50	4	54	50	52	133,913	566	502	+ 12.7	1,678,282	33	39	39
Dist. 2—Middle Gulf	28	3	8	20				59		59	53	59	340,497	657	738	— 11.0	3,839,911	43	51	46
Dist. 3—Upper Gulf	79	1	4	39				123	1	124	149	101	706,537	1,397	1,118	+ 25.0	8,310,362	125	136	135
Dist. 4—Lower Gulf-SW.	58		14	41				113	1	114	114	156	555,936	1,345	1,461	— 7.9	6,670,508	111	100	122
Dist. 5—E. Central	4	1	1	11				17		17	11	29	86,444	196	244	— 19.7	923,918	21	24	28
Dist. 6—Northeast	57	5	2	11				75		75	53	45	355,580	890	731	+ 21.8	3,959,667	42	43	41
Dist. 7-B—N. Central	86		4	52		1		143		143	173	142	400,043	1,902	1,470	+ 29.4	5,587,088	167	175	235
Dist. 7-C—W. Central	35			18				53	3	56	66	46	235,464	511	424	+ 20.5	2,248,094	90	86	80
Dist. 8—West	186			21				207	6	213	272	286	1,161,249	2,883	2,991	— 3.6	14,252,050	479	459	449
Dist. 9—North	155			98		1	1	255	2	257	224	248	692,050	2,668	2,293	+ 16.4	7,312,654	181	173	147
Dist. 10—Panhandle	59		24	2				85		85	93	65	271,570	1,097	624	+ 75.8	3,533,559	106	98	170
Utah	1			3				4		4	2	2	15,605	57	20	+185.0	283,899	8	12	11
Virginia											1			1	2	— 50.0	7,401	1	1	
Washington				1				1		1		1	9,344	1	11	— 90.9	9,344		1	
West Virginia	10		32	8				50	1	51	72	75	134,785	512	850	— 39.8	1,450,058	242	256	362
Wyoming	27		1	18				43		43	57	42	211,797	603	526	+ 14.6	2,846,544	91	106	123
Total United States	1,754	24	244	1,053	64	12	9	3,160	31	3,191	3,665	3,515	11,224,147	38,999	40,010	— 2.5	137,999,453	4,355	4,485	4,908

Looking Ahead

BUSINESS IN 1950's first half will continue at level of latter 1949, according to a survey of U.S. business leaders. Few expect downturn before June.

U.S. BUSINESSES expect to spend $3820 million for new plants and equipment in first quarter, according to Securities and Exchange Commission. This would be 14 percent less than was spent in first quarter of last year and 8 percent below first quarter of 1948.

ALARM AT THE THREATENED SHRINKAGE of state income if the Railroad Commission continues to reduce allowables was expressed by Gov. Allan Shivers of Texas. Governor noted that quotas have been cut 250,000 barrels per day since November, including a 36,000 barrels daily reduction (down to 2,100,000) for February.

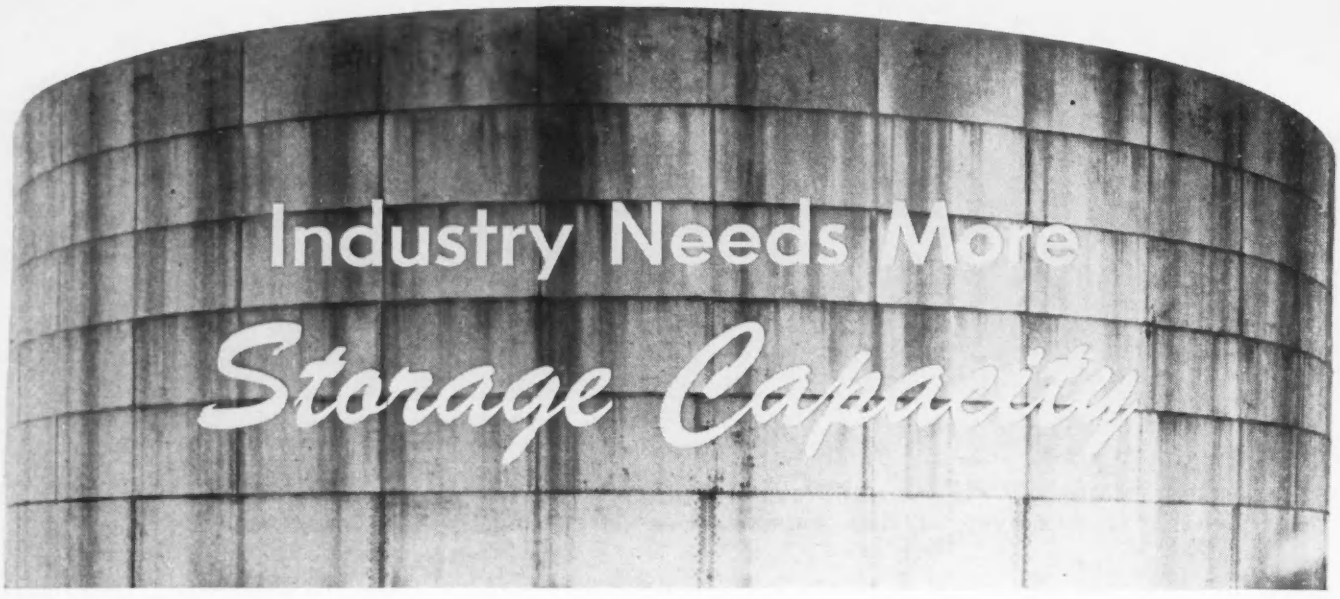
TIME IS APPROACHING when President Truman will be forced to use Taft-Hartley machinery to restore full coal production. President in late January refused even to guess when emergency might develop that would prompt him to send miners back on a five-day work week, but situation was growing more critical as he spoke.

TECHNOLOGICAL RESEARCH will result in heavy investment in new equipment to create new markets for the goods demanded by a constantly improving standard of living. That is the expressed view of Murray Shields, vice president and economist of the Bank of the Manhattan Company, New York, who further predicts good business conditions during the first months of 1950 followed by a moderate slump.

THE API PRODUCTION DIVISION will remain in Dallas rather than be moved to New York, if the Colley Committee recommendations are accepted by the API directors. The Colley Committee, which has been studying structural changes for the API, has presented its report which will not be disclosed until acted on by the API. It has been learned, however, that the report suggests no territorial change be made in the Institute's production division.

GASIFICATION of high carbon bunker oils, now available in greater quantities at low cost, will provide a large volume of high BTU gas. More than 30 companies have installed or are planning to install flexible, low cost oil processes (the Hall process) to provide adequate gas supplies for peak winter demands.

WHAT TO EXPECT for the industry in 1950 will be set forth concisely and graphically in numerous carefully prepared forecasts and surveys in WORLD OIL's annual review-forecast number February 15. State conservation bodies, U.S. government agencies, and many oil companies and individuals have cooperated with WORLD OIL to make possible these valuable forecasts of industry operations. Also embodied in the issue will be salient statistics on industry operations and trends of the past, representing valuable material for future reference and use.



Industry Needs More Storage Capacity

DESPITE LARGE over-all expansion since the war, the industry needs further important expansion insofar as storage facilities are concerned. Storage capacity has not been kept in line with increased demand for petroleum products, especially as regards heating oil. To assure adequate supplies in times of severe winter weather, more heating oil storage capacity is needed at all levels—primary, distributor, and consumer. More heating oil storage indirectly would also help assure adequate gasoline for peak summer demand, as clean fuel oil tanks can be converted for gasoline storage if needed.

DOES the petroleum industry have sufficient existing storage capacity to guarantee ample supplies of gasoline in summer and fuel oil in winter so that the consuming public faces no danger again of laying up cars in summer or going cold in winter because of shortages resulting from unexpected peak seasonal demands on inventories? If such storage facilities are not adequate, where should they be built, by whom and in what amount?

An extensive survey just completed by WORLD OIL shows:

- Gasoline storage capacity is adequate.
- Fuel oil storage capacity is not adequate—at any level, primary, secondary or consumer.

Industry economists are generally agreed that supply is chiefly a storage problem rather than a production or a refinery yield problem. This is so expressed, for instance, by Stanley C. Hope, president of Esso Standard Oil Company, who says:

> "In our opinion, to attempt to meet this seasonal problem primarily by enlarged refinery capacity and adjustment of yields would be uneconomic and therefore ultimately result in high prices to the public. It is our belief that the economic approach to the problem is to plan more nearly even year-round refinery throughputs and to provide necessary storage facilities to absorb the season fluctuations in demand."

The same argument is made by Stewart P. Coleman, a Jersey Standard director, who says:

> "In the long run more storage would seem to be the answer to the problem of evening out the fluctuations in industry operations caused by seasonal fluctuations in both volume and nature of demand. The investment required for storage for this purpose is but a small fraction of that for the spare capacity that must otherwise be provided in all functions of the industry if the demand swings fall directly on operations. From the standpoint of consumer relations, such storage also has the desirable effect of reducing seasonal price fluctuations, and national defense objectives are also aided by availability of greater over-all storage."

Because of the changing seasonal nature of the petroleum industry the storage problem now chiefly concerns fuel oil. K. E. DeRosay, manager of fuel oil sales for Sun Oil Company, says:

> "All evidence points to the fact that winter peak loads will become more pronounced in the future. Furthermore, the future potential increase in heating oil demand is considerably greater than the potential increase in gasoline demand."

This fact is substantiated by Dr. Courtney C. Brown, Standard Oil Company (N.J.) economist, who points out that from 1932 to 1948 demand for all petroleum products doubled, with an average yearly compounded increase of 6 percent, but that in the same period demand for light heating oils increased 10 percent, while the gain for gasoline was only 5.4 percent.

One index of storage adequacy is computed by the Bureau of Mines in its "days supply" figure. This statistic is obtained by dividing the amount of total stocks at a given date (end of the

TABLE 1
Indicated Days Supply of All Oils

	1945	1946	1947	1948	1949
January	83	85	83	76	96
February	82	87	80	78	99
March	83	92	83	79	100
April	82	89	85	82	107
May	80	88	88	87	112
June	81	91	88	87	110
July	84	94	87	90	111
August	88	96	92	92	101
September	93	102	86	97	100
October	96	99	85	99	104
November	92	95	85	98	...
December	88	85	75	92	...

From Bureau of Mines Monthly Petroleum Statements.

TABLE 2
Total Demand (including exports)
(Bureau of Mines figures in 42 Gallon Barrels)

	Total Stocks As of Sept. 30	Total Demand for 6 Months Oct.-March Inclusive	Index Figure
Kerosene:			
1945–1946	13,675,000	55,983,000	1:4.1
1946–1947	21,251,000	64,815,000	1:3.0
1947–1948	22,276,000	73,725,000	1:3.3
1948–1949	26,062,000	67,924,000	1:2.6
1949–1950	26,650,000	....	....
Distillate Fuels:			
1945–1946	45,059,000	152,433,000	1:3.4
1946–1947	62,019,000	178,760,000	1:2.9
1947–1948	59,764,000	218,398,000	1:3.7
1948–1949	72,385,000	215,081,000	1:3.0
1949–1950	82,213,000	.....	....

month) by the daily average current demand for the same month. The quotient is the number of days that current demand could be satisfied from current inventory.

Table 1 compiled by the Bureau shows this index figure of "days supply" for the end of each month from January, 1945, to October, 1949.

The table shows that at the beginning of the heating season last year the "days supply" was greater than at any corresponding date for the last five years. However, the index is obviously heavily overweighted by the gasoline component as inspection of the April and May figures reveal.

Fred Van Covern, chief statistician for the American Petroleum Institute, factored out the fuel oil component and derives an index which tells a more significant story as far as heating oil storage is concerned. Van Covern takes only kerosine and distillate as against the Bureau's composite stock figure of all oils. Then he considers the heating season—the six months from October to March, inclusive—adds total demand for this half-year period and divides the sum into the stock figure of the product concerned for Sept. 30 (beginning of the heating season in question).

Table 2 sets forth the Van Covern procedure. From these figures it is evident that increased stocks of one product, such as a 1-million barrel stepup in kerosine for 1947-48 over the preceding year, does not guarantee an index number indicating relatively greater supply.

How much total storage capacity is there in the U. S.? To answer that question we must distinguish at least three levels of storage (excluding the retail level except for burning oils). These levels are (1) primary storage, which is chiefly major company storage and primarily refinery storage; (2) secondary storage, which is jobber-distributor; and (3) consumer, representing the total capacity of fuel oil tanks in the homes of the nation.

The only accurate and official figures which have ever been compiled cover primary storage only, and this discussion is chiefly concerned with the primary level. However, estimates exist of the storage available at the other levels. For instance, Robert Gray, business manager of *Fuel Oil and Oil Heat*, concludes from a survey taken by his organization that fuel oil distributor storage amounted to 24,244,267 barrels as of January 1, 1950. A careful check of consumer tanks yields an average capacity figure of 393 gallons, and Oil Heat Institute figures show currently 4,499,916 burners of No. 2 and No. 3 oil in the country. This would yield a consumer storage capacity of 41,642,000 barrels.

The most exhaustive study of primary storage ever made was conducted by the Committee on Petroleum Storage Capacity of the National Petroleum Council, published in October, 1948. Despite the fact that this survey is more than a year old, its relationship of figures for purposes of analysis is considered still valid. The study was made on the basis of questionnaires to 323 companies.

The significant facts brought out by this project were:

● Sixty-five percent, or about two-thirds of total crude oil inventories, represents unavailable stocks. California was the highest individual district with 68 percent, and District 4 the lowest with 53 percent.

● Total tankage for the storage of crude oil at refineries, tank farms, etc. for the country as a whole totalled 416,727,000 barrels, including reservoir storage in California of 2,527,000 barrels

■ CONTINUED ON PAGE 48

Capacity of Crude Oil, Clean Product and Residual Fuel Oil Tankage as of March 31, 1948

***Note:* Figures are shown in Barrels of 42 U. S. Gallons by Bureau of Mines refining districts and include all tankage available for storing Crude Oil, Clean Products and Residual Fuel Oil, as shown below, but deal only with the tankage that is located at the points (Refineries, Pipe Lines, Tank Farms and Terminals) included in the stock figures regularly reported to the Bureau of Mines on Forms 6-1311 Crude (except Producers' Lease Stocks), and Product Forms 6-1300; 6-1302 and 6-1303, East of California, and the corresponding forms in California. They do not include tankage at bulk plants, service stations, etc.**

	East Coast	APPALACHIAN		Indiana Illinois Kentucky	Oklahoma Kansas Missouri	Texas Inland	Texas Gulf	Louisiana Gulf	Arkansas-Louisiana Inland	New Mexico	Other Rocky Mountain	California	Total United States
		District I	District II										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
CRUDE OIL TANKAGE													
1. Capacity of Tankage at Refineries	19,023,215	964,018	231,952	12,806,704	14,942,646	5,064,155	22,584,105	7,505,197	1,041,000	67,000	5,909,442	17,557,072	107,696,506
2. Capacity of Tankage along Pipe Lines and on Tank Farms	2,563,500	4,313,107	2,888,864	24,549,047	65,199,498	77,329,133	57,202,640	8,690,726	9,540,010	2,100,484	12,615,444	42,038,283	309,030,736
Total Crude Oil Tankage Capacity (1) and (2) above	21,586,715	5,277,125	3,120,816	37,355,751	80,142,144	82,393,288	79,786,745	16,195,923	10,581,010	2,167,484	18,524,886	*59,595,355	*416,727,242

NOTE: Tankage involved in Producers' (Lease) Stocks not included. * Includes 2,527,000 barrels of reservoir storage in California.

CLEAN PRODUCTS

(These include only Gasoline, Kerosene and Distillate Fuel Oil and deal only with the tankage at the locations of inventories regularly reported to the National Bureau of Mines.)

1. Capacity of Tankage at Refineries	23,603,613	2,934,432	1,225,270	34,598,373	16,892,231	5,900,793	49,271,475	11,793,981	2,021,854	195,190	7,322,425	44,132,982	199,892,619
2. Capacity of Tankage along Pipe Lines and on Tank Farms	4,720,233	533,500	537,402	9,349,365	3,117,720	1,446,007	1,817,868	1,649,260	2,072,900	.....	195,754	6,656,029	32,096,038
3. Capacity of Tankage at Bulk Terminals	46,040,451	1,591,658	1,385,745	16,327,435	4,491,030	40,000	3,195,779	3,230,418	1,589,926	1,600	150,634	9,725,702	87,770,378
Total Clean Product Tankage Capacity—(1), (2) and (3) above	74,364,297	5,059,590	3,148,417	60,275,173	24,500,981	7,386,800	54,285,122	16,673,659	5,684,680	196,790	7,668,813	60,514,713	319,759,035

RESIDUAL FUEL OIL

(This deals only with the tankage at the locations of inventories regularly reported to the National Bureau of Mines.)

1. Capacity of Tankage at Refineries	7,472,543	455,262	383,392	8,259,352	4,034,104	1,705,097	9,968,704	3,291,728	382,182	62,050	1,888,562	42,775,520	80,678,496
2. Capacity of Tankage along Pipe Lines and on Tank Farms	.....	.....	.....	260,000	.....	.....	.....	.....	.....	.....	.....	29,491,540	29,751,540
3. Capacity of Tankage at Bulk Terminals	7,101,872	.....	.....	294,277	.....	.....	746,823	433,915	48,600	.....	.....	4,324,456	12,949,943
Total Residual Fuel Oil Tankage Capacity—(1), (2), and (3) above	14,574,415	455,262	383,392	8,813,629	4,034,104	1,705,097	10,715,527	3,725,643	430,782	62,050	1,888,562	†76,591,516	†123,379,979

† Includes 41,573,510 barrels of reservoir storage in California.

A Uniform Plan for Applying Oil Conservation Laws Within a State

By PARK J. JONES
Consultant, Houston, Texas

A UNIFORM PLAN for applying conservation laws within a state is proposed and outlined. The proposed method is intended for all newly discovered oil reservoirs and for as many of the developed oil reservoirs as can be prorated by the method. It covers conservation, development, and production. The proposed plan would require the cooperation of operators, landowners, and the state.

IT is believed that conservation laws can be applied so as to maximize the ultimate oil recovery, minimize the drilling of unnecessary wells on small tracts and certain edge leases and minimize the unnecessary production of gas and water. It is also believed that landowners and operators should have an opportunity to protect themselves against the loss of oil by migration.

Cooperation between the leases on a reservoir gives operators an opportunity to ascertain and apply the optimum producing method. But, because of the many factors, no two reservoirs are alike. The optimum producing method has to be ascertained for each particular reservoir through cooperation. The plan here proposed offers an inducement for cooperation between the leases on a reservoir.

In-Place Oil at Saturation Pressure

The saturation pressure is that at which a reservoir liquid starts vaporizing. The pressure in an oil reservoir at the time of discovery may be either equal to or greater than the saturation value.

The oil in-place at saturation pressure for a lease in any one of its underlying reservoirs is defined by

$$I = 7758\,ahf(1 - W)/b \qquad (1)$$

where

- a = proved productive acres
- h = average oil pay thickness for the proved acres, ft.
- f = average porosity for the ah acre-feet, fraction
- W = average interstitial water for the porosity, fraction
- b = volume factor at saturation pressure, bbls. space/bbl. oil
- I = estimated in-place oil for a lease, bbls.

The estimated in-place oil at saturation pressure for any one reservoir underlying a field is equal to the sum of the corresponding values defined by equation (1).

The effective gas and/or water ratio is expressed in terms of b the volume factor for oil at saturation pressure, and b barrels of water, or an equivalent volume of free gas, is required in order to displace one barrel of oil. If B is the volume factor for free gas, then b/B cubic feet of gas will displace one barrel of oil at saturation pressure where

$$B = \frac{0.005035TZ}{P} \qquad (2)$$

in which

- B = bbls. of space/cubic foot of gas
- P = reservoir pressure, psia
- T = reservoir temperature, °R
- Z = compressibility factor

The effective ratio for a lease is given by

$$F = 1 + \frac{B}{b}(G - g - H) + \frac{V - W}{b} \qquad (3)$$

where

- F = effective ratio, no dimensions
- G = producing gas-oil ratio, cu ft/bbl.
- g = gas at saturation pressure, cu ft/bbl.
- H = injection gas-oil ratio, cu ft/bbl.
- V = producing water-oil ratio, bbls. water/bbl. oil.
- W = injection water-oil ratio, bbls. water/bbl. oil.

If oil is recovered without producing water and without injecting gas,

$$F = 1 + \frac{B}{b}(G - g) \qquad (4)$$

If oil is recovered with a gas-oil ratio equal to g or less, the effective ratio is taken at unity aside from producing water. An effective ratio, if less than unity as defined by equation (3), is assumed to be unity. High effective ratios may be reduced by workovers, shutting in wells or by injection of gas and/or water.

The effective ratio for a reservoir is given by

$$E = J/\Sigma\left(\frac{I_i}{F_i}\right) \qquad (5)$$

where

- I_i = estimated in place oil by leases, bbls.
- F_i = effective ratio by leases
- $J = \Sigma I_i$ = estimated in place oil for a reservoir, bbls.
- E = effective ratio for a reservoir.

It should be emphasized that the effective ratio E for a reservoir is based on the per-lease in-place oil and effective ratio. As cooperation is the essence of the proposed plan, it should also be emphasized that the need for a clear definition of the word "lease" for conservation purposes is paramount.

The in-place oil by leases may be changed through development, extension of reservoir, and through merging or unitizing two or more leases for conservation purposes. Two leases need not be contiguous in order to form one lease for the purpose of conservation. This is another point which needs clarification. In addition, it should also be noted that the g in equation (3) may include through cooperation the free gas in a primary gas cap in accordance with equation (8) below.

The Allowable Producing Rate

The allowable for a proratable oil reservoir within a state is defined by

$$R_i = \frac{J_i/E_i}{(J_i/E_i)} \cdot P \qquad (6)$$

where

P = proratable oil within a state, bbls/calendar day

J_i = in-place oil at saturation pressure for a proratable reservoir, bbls.

E_i = the effective ratio for a proratable reservoir

R_i = allowable for a reservoir, bbls/calendar day.

The allowable for a lease on a prorated reservoir is defined by

$$L_i = R \cdot \frac{I_i}{J} \qquad (7)$$

where

R = reservoir allowable from equation (6)

I_i = in-place oil by leases from equation (1)

J = in-place oil for reservoir = ΣI_i

L_i = lease allowable, bbls/calendar day.

Under the proposed plan, the per-lease opportunity to produce oil is proportional to the per-lease initially in place oil. Even so, the procedure may not fully protect edge leases against the loss of oil by migration.

Oil Production by Solution Gas

Consider an oil reservoir which has no primary gas cap and into which the rate of water encroachment upon declining pressure is negligible. For illustrative purposes let the gas in solution at saturation pressure be 400 cubic feet per barrel; the volume factor, 1.2 barrels per barrel; and 800 cubic feet of gas are required to displace one barrel of oil. For no injection of gas or water the effective ratio and the relative allowable in the course of time could be as follows:

Case A

Producing GOR for reservoir	400	800	1200
Effective ratio for reservoir	1.0	1.5	2.0
Relative allowable, percent	100	66.7	50.0

The effective ratio is here equal to unity as long as the GOR for the reservoir considered as one lease does not exceed 400. However, at the time the producing GOR increases to 1200, the effective gas-oil ratio would be 2.0 and the allowable would be only 50 percent of what it was for the unit effective ratio. This is an inducement for minimizing the unnecessary production of gas.

Consider another oil reservoir which has no primary gas cap and into which the rate of water encroachment upon declining pressure is negligible. For illustrative purposes let the gas in solution at saturation pressure be 800 cubic feet per barrel; the volume factor, 1.4 barrels per barrel; and 3000 cubic feet of gas are required to displace one barrel of oil. For no injection of gas or water the effective ratio and the relative allowable in the course of time could be as follows:

Case B

Producing GOR for reservoir	800	1600	2400
Effective ratio for reservoir	1.00	1.27	1.53
Relative allowable, percent	100	78.9	65.4

The effective ratio is here equal to unity as long as the producing GOR does not exceed 800. However, at the time the producing GOR increases to 2400, the effective ratio would be 1.53 and the allowable would be 65.4 percent of what it was at the unit effective ratio. Cases A and B are cooperative or unit operations for which the entire reservoir is taken as one lease for the purpose of proration.

Injection of Solution Gas

Suppose 80 per cent of produced gas is injected. The conditions for Case A would be as follows:

80 Percent Injection for Case A

Producing GOR	400-2000	4000	8000
Injection GOR	320-1600	3200	6400
Net, GOR	None	400	1200
Effective ratio	1.0	1.5	2.5
Relative allowable, percent	100	66.67	40.00

In this example the solution GOR is 400. Hence the effective ratio is taken at unity as long as the producing GOR does not exceed two MCF per barrel, see equation (3). For oil produced with a GOR greater than 2000, the effective ratio increases and the allowable decreases because 800 cubic feet of gas are required to displace one barrel of oil at saturation pressure. The net producing GOR as defined by equation (3) is the producing GOR less 400 less the injection GOR.

The conditions for Case B with 80 percent gas injection would be as follows:

80 Percent Injection for Case B

Producing GOR	800-4000	8000	16,000
Injection GOR	640-3200	6400	12,800
Net GOR	None	800	2400
Effective ratio	1.0	1.26	1.80
Relative allowable, percent	100	79.36	55.55

In this example, the net GOR as defined by equation (3) is the producing GOR less 800 less the injection GOR. Hence the effective ratio is taken at unity as long as the producing GOR does not exceed four MCF per barrel. For oil produced with a GOR greater than 4000, the effective ratio increases and the allowable decreases because 3000 cubic feet of gas are required to displace one barrel of oil at saturation pressure.

Both of the foregoing examples are based on the assumption that through cooperation all the leases on a reservoir may be considered as one lease for the purpose of proration.

The Secondary Gas Cap

Consider a reservoir which has a high permeability so that a secondary gas cap is growing under the structurally-high leases. Let the rate of water encroachment be nominal. Oil is migrating away from the high leases and their GOR would increase progressively. During several years the conditions could be as follows:

Case C, Early Stage

Leases	High	Others	Reservoir
Initial oil, percent	20	80	100
Effective ratio	2	1	1.111
Relative allowable, percent	18.0	72.0	90.0

Case C, at A Later Stage

Leases	High	Others	Reservoir
Initial oil, percent	30	70	100
Effective ratio	5	1	1.316
Relative allowable, percent	22.8	53.2	76.0

During an early stage in the life of the reservoir, the structurally-high leases containing 20 percent of the initial oil could be producing with an effective

About the Author

PARK J. JONES has been in consulting work, specializing in all phases of production, since August, 1944. He had a broad background of oil field experience as a roustabout, roughneck, junior engineer and engineer in fields in California, New Mexico, Texas, Louisiana, Oklahoma, Illinois and Colorado. His work on cycling and the production of condensate in Texas and Louisiana has been widely recognized. Jones was graduated from the University of California in 1931, with a B.S. degree in petroleum engineering and geology, and has since done graduate work.

ratio of 2.0. The latter would reduce the reservoir allowable to 90 percent of what it would be for a unit effective ratio.

At a later stage, the secondary gas cap could enlarge to include leases containing 30 percent of the initial oil. These structurally-high leases could be producing with a 5.0 effective ratio. The latter would reduce the reservoir allowable to 76 percent of what it would be for a unit effective ratio.

Under the proposed plan, royalty and working interests would be likely to cooperate before the effective ratio for the structurally-high leases reached 5.0. However, during the interim of increasing gas-oil ratios, the structurally-high leases are not protected against the loss of oil by migration.

Encroaching Edge Water

Consider an undersaturated oil reservoir into which edge water advances upon declining pressure. Oil production is by water displacement aside from the comparatively nominal oil recovery by expansion of the in-place reservoir liquid. Oil is migrating to the leases on the updip side of those along the water contact. During several years the conditions could be as follows:

Case D, Early Stage

Leases	Low	Others	Reservoir
Initial oil, percent	30	70	100
Effective ratio	2.0	1.0	1.176
Relative allowable, percent	25.50	59.50	85.0

Case D, at A Later Stage

Leases	Low	Others	Reservoir
Initial oil, percent	50	50	100
Effective ratio	5.0	1.0	1.667
Relative allowable, percent	30	30	60

During an early stage in the life of the reservoir the structurally-low leases containing 30 percent of the initial oil could be producing with a 2.0 effective ratio. The latter would reduce the reservoir allowable to 85 percent of what it would be for a unit effective ratio.

At a later stage, the encroaching water could have invaded the leases containing 50 percent of the initial oil. These leases could be producing with a 5.0 effective ratio. The latter would reduce the reservoir allowable to 60 percent of what it would be for a unit effective ratio.

Under the proposed plan, royalty and working interests would be likely to cooperate before the effective ratio for the structurally-low leases reached 5.0. However, during the interim of increasing water-oil ratios, the structurally-low leases are not protected against the loss of oil by updip migration. If the effective ratio did go to 5.0, the leases nearest to water may not be capable of producing their allowable because of the high water cut. If so, the rate of production from the reservoir would be less than the allowable rate.

The Primary Gas Cap

Consider an oil reservoir which has a primary gas cap. Its free gas content at the time of discovery can be estimated with the aid of equations (1) and (2). Considering the reservoir as a whole, the gas associated with a barrel of in-place oil is defined by

$$g = g_o + \frac{b}{B}\left(\frac{y}{1-y}\right) \qquad (8)$$

where

g = free and solution gas, cu ft/bbl oil
g_o = solution gas, cu ft/bbl oil
y = fraction of total reservoir space above the initial gas-oil contact
b = volume factor for oil
B = volume factor for gas.

Consider an oil reserve for which the primary gas cap occupies 50 percent of the total reservoir space at the time of discovery. For illustrative purposes, let the solution GOR be 800; the volume factor for oil, 1.4 and ratio of oil to gas volume factors b/B, 3000. By equation (8), there is a total of 3800 cubic feet of gas per barrel of oil. The free gas is 3000/3800 or 78.95 percent of the total gas initially in the reservoir.

If only the oil pay is considered as one lease for proration purposes, the effective ratio would be based on the 800 solution gas GOR and the 3000 cubic feet of gas required to displace one barrel of oil. This is the same as Case B already considered above.

If the oil pay is considered as several leases the effective ratio would be on a per-lease basis in terms of the 800 and 3000 values. In the course of time, the conditions could be as follows:

Leases	Near Gas Cap	Others	Reservoir
Initial oil, percent	50	50	100
Producing GOR	4800	800	...
Effective ratio	2.333	1.0	1.667
Relative allowable, percent	30.0	30.0	60.0

This is a material inducement for cooperation between the oil leases in this example.

Next consider the oil and gas leases combined as one lease for proration purposes. By doing so the basis for calculating the effective ratio by equation (8) is increased in this example from 800 to 3800 cubic feet per barrel of oil. That is, production would be at unit effective ratio as long as the producing GOR did not exceed 3800 for the reservoir as a whole. This is a material inducement for cooperation between the gas leases on the one hand and the oil leases on the other. Of course, the produced gas would have to be injected into the producing reservoir, sold or stored.

If cooperation between the gas and oil leases is achieved but production is from several leases, the effective ratio would be on a per-lease basis in terms of the 3800 and 3000 values. In the course of time, the conditions could be as follows:

Leases	Near Gas Cap	Others	Reservoir
Initial oil, percent	50	50	100
Producing GOR	4800	800	...
Effective ratio	1.333	1.0	1.167
Relative allowable, percent	42.85	42.85	85.70

The allowable is now 85.70 rather than the preceding 60.0 percent. In other words, the proposed plan tries to protect the leases underlain by a primary gas cap as well as the leases underlain by oil. An inducement for cooperation all along the line to the extent required for minimizing the unnecessary production of gas is the essence of the proposed plan. A similar statement holds for the unnecessary production of water and also for minimizing the drilling of unnecessary wells.

Flexibility of the Plan

The examples here included illustrate only a very few of the many conditions found in the field. However, equation (3) is thought to be general enough to define the per-lease effective ratio for nearly all possible combinations of gas and/or water production and injection.

The data required for the application of the proposed plan are as follows: Per-lease proved in-place oil and/or gas, the volume factors for oil and free gas and the quarterly producing and injection gas and water ratios by leases. But, for nominal changes in gas and/or water ratios, annual ratio data may be used. It also appears that a definition of a lease for proration purposes is necessary.

The Transition Period

The proposed method is intended for all newly discovered oil reservoirs and for as many of the oil reservoirs already developed as can be prorated by the method. If some fields could not be prorated by the proposed method, there would be a transition period during which some of the proratable oil would

have to be allocated by the prevailing methods.

On the other hand, there is no advantage in producing gas and water unnecessarily. It is probable that the operators on many of the oil fields already developed would work out a cooperative operation in line with the proposed plan because of its advantages. However, there would not be cooperation in the fields producing oil primarily by migration, short of enforcing the proposed method for the protection of correlative right. Of course if more than 50 percent of the leases on a reservoir are losing oil by migration, the proposed plan probably could be enforced upon the leases into which oil is migrating. There is no advantage for example in producing millions of barrels of water unnecessarily.

The Optimum Rate

A rate of depletion much in excess of the optimum causes waste by virtue of well, plant and field system capacity much larger than is required at the optimum rate. Throughout the discussion on proratable oil it was assumed that the allowable is less than the optimum rate. If the allowable is higher than the optimum, operators may under the proposed plan elect the optimum rate and a reservoir would not be proratable. However, reservoirs not prorated are subject to the same waste prevention rules that apply to the prorated reservoirs.

The procedure for applying conservation laws in a state not having proration will now be outlined. The effective ratio E for a reservoir is given by equation (5). Let Q be the optimum producing rate in barrels per calendar day. Then the rate of production from a reservoir is Q/E barrels per day where E is the reservoir quarterly effective ratio based on the per-lease quarterly effective ratio as defined by equation (3). The per-lease producing rate is given by

$$L_i = \frac{I_i}{J} \cdot \frac{Q}{E} \qquad (9)$$

where

I_i = in place oil by leases from equation (1)
J = in place oil for a reservoir
L_i = lease producing rate, bbls/calendar day.

Under the proposed plan, the per-lease opportunity to produce oil is proportional to the per-lease initially in place oil. Even so, the procedure may not fully protect edge leases against the loss of oil by migration.

The proposed method of applying conservation laws in a state not having proration is the same as that for a state which does have proration of oil except that the optimum rate is used rather than the allowable rate. The plan should be applied throughout the interim of unnecessarily high gas-oil and/or water-oil ratios. In the examples already considered, relative producing rate may be read for relative allowable. If the producing capacity of a lease is less than its producing rate or allowable, the difference is not transferable to other leases on a reservoir.

The Small Tract

It should be emphasized that a definition of a small tract varies with economic and physical circumstances. Through cooperation a small tract may be included with another lease or other leases. Under the proposed plan, the small tract opportunity to produce oil is proportional to its initially in-place oil provided there is a reasonable cooperation. Contiguousness is not required.

The operators for the leases on a reservoir should try to arrive at unanimous recommendations to the state. The small tract should be defined by the operators on a reservoir. The state permits the drilling of a well on a small tract and gives it a marginal allowable if at a hearing by the state the small tract operator shows that cooperation is not reasonable. But, when cooperation is reasonable, a well may not be drilled on a small tract.

It might be of interest to note that one acre of productive area is not necessarily a small tract from the viewpoint of reserve in a field underlain by many oil reservoirs. Nevertheless, operators could define a one-acre lease as a small tract on the basis of a reasonable separation between wells according to depth.

Several Reservoirs in One Trap Zone

When the reservoir portion of one trap zone is faulted, a field may have several oil reservoirs in the one trap zone. But such reservoirs are separated areally and a group of wells completed in one reservoir cannot be utilized in another. Each reservoir has its own allowable according to the proved initially in-place oil corrected for the per-reservoir effective ratio. A lease may be underlain by more than one reservoir. There is a need for cooperation between the leases on each reservoir and also between those on the different reservoirs. The market demand for the oil from the field may be less than the optimum depletion rate for all the reservoirs combined.

The operators for the leases and the reservoirs should recommend to the state whether they elect to produce a few of the reservoirs at the optimum rate or all of the reservoirs at the allowable rate with the understanding that the optimum rate for a few of the reservoirs shall not exceed the allowable rate for all the reservoirs. There can be a material advantage to the state and the landowners and operators through such cooperation. It is also understood that the landowners and operators not having current production are protected through cooperation.

Multiple-Reservoir Field

A field may have several oil reservoirs at various depths. Most of the productive area of the smaller reservoirs may be within the downdip limit of the productive area for the largest underlying reservoir. This is a multiple-reservoir field. For such fields there are two methods for locating wells and producing reservoirs. Parallel operations refer to producing two or more reservoirs simultaneously. Series operations refer to producing two or more sets of reservoirs one set after another with a given group of wells. A series operation requires many reservoirs in order to have several groups of wells producing in parallel.

A lease may be underlain by 5, 10, 20 or even more reservoirs. A lease near a structural culmination may be underlain by all reservoirs. A lease at one end of a multiple-reservoir field may be underlain by a greater or a lesser number of reservoirs than there are under another structurally similar lease at the opposite end of the field. The need for cooperation with respect to locating and completing wells and formulating producing methods is outstanding. The cooperation is between the leases underlain by a reservoir and between the reservoirs underlying a field.

The operators for the leases and the reservoirs should try for unanimous recommendations to the state. The recommendation as to the proved initially in-place oil should be so as to have a higher in-place oil upon having drilled additional wells. Each additional recommendation should show a higher initially in-place oil.

The operators should recommend to the state whether they elect to produce some of the reservoirs at the optimum rate or all of the reservoirs at the allowable rate for the field. It is understood that the optimum rate for some of the reservoirs shall not exceed the allowable rate for all the reservoirs underlying the field. It is also understood that the landowners and operators not having current production are protected through cooperation.

The advantages of cooperation to operators, landowners, the state and the nation cannot be overemphasized. The optimum producing method includes conservation, development and production. Oil operators can achieve the optimum producing method if enabled to do so through cooperation.

If a state line runs through a field, the suggestion is (a) that the state not

having proration yield to the state having proration (b) that, if the states do have proration, the state or states having the higher allowable depletion rate yield to the state having the lesser allowable depletion rate and (c) that, if proration is not involved, let the operators in such a field submit a recommendation to the interested states.

Reservoir vs. Reservoir

Under the proposed plan, there is no connection between geographically separated reservoirs in a state not having proration of oil. But in a state which does have proration, the operators of a field are interested to some degree in the recommendation by the operators as to the proved in-place oil for other fields. In other words, the recommendation as to initially in-place oil made by the operators of a field should be open to question by the operators of the other fields in a state. A state should be cautious in its procedure for attesting the proved initially in-place oil for a reservoir. Similar considerations apply to the periodic recommendation made by operators and attested by a state as to the effective ratio for a reservoir.

In the event that the status of a reservoir as to in-place oil and/or the currently effective ratio be questioned, all those concerned should meet and if agreement is not reached, request a hearing by the state. A state should require an operators meeting before a hearing by the state.

Proration of the Primary Gas Cap

A strict application of the optimum producing methods in a state having proration of oil and gas would require an additional rule under the plan herein proposed. This rule could be as follows: The gas necessarily produced with oil shall be marketable contemporaneously with the gas from condensate and natural gas reservoirs provided that the depletion rate to market of a primary gas cap in an oil reservoir shall not exceed the depletion rate to market from condensate and natural gas reservoirs.

Conclusion and Acknowledgment

A uniform plan for applying conservation laws within a state has been outlined. The writer is not a lawyer, and the terminology here used may have to be changed to meet legal requirements. Originality is not claimed. On the other hand, the writer is not in a position to examine conservation literature and give credit where it is due. So in conclusion, acknowledgment is made to all who have contributed to the methods of applying conservation laws.

Storage Capacity Needed

■ CONTINUED FROM PAGE 41

as against 177,480,000 barrels actually contained in these facilities on the date of check.

● More than 30,579,000 barrels of crude are required to fill tank farm and main trunk pipe lines, and 5,165,000 as fill for crude oil carrying tankers, barges, tank cars and trucks.

● That about 100 million barrels of crude are required to assure continuous operation of pipe lines and refineries and the handling and blending of the various grades of crude oils.

About one half of all product storage is needed for continuous operation and is therefore unavailable for consumption. One of the interesting findings of this survey is the large storage capacity required to maintain normal flexibility of operations, over and above that actually occupied by current inventories. For instance, there were about 100 barrels of storage capacity for every 41 barrels of inventory.

But in no case is the difference between these inventories and capacity figures an indication of available storage space. The committee warned that "long term operating experience indicates that anything higher than a 70 percent product-tankage relationship will begin to develop difficulties while in other installations even a considerably smaller relationship causes operating problems."

On September 1, 1949, stocks of oils of all producers, refiners, in pipe lines and in wholesalers' tanks (excluding all retail stocks) totalled 623.7 million barrels. Of this amount only 284.1 million barrels were available. Hence 339.6 million barrels were necessary as the backlog of the industry's working stocks. Such figures point up the storage problem sharply—storage capacity must be far in excess of actual inventories.

For the heating oils—the heart of the storage problem—that capacity is not currently adequate at any level, in the opinion of most industry economists.

Unavailable Stocks as of March 31, 1948, for the U. S.
(Condensed from NPC Report)
(In 42 Barrels)

CLEAN PRODUCTS
(Gasoline, Kerosine, Distillate Fuels)

1. Amount reported to B. of M. as at refineries, terminals or in pipe lines or in transit	149,903,482
2. Analysis of unavailable stocks in 1 above:	
a. Tank bottom credit 7 percent	22,262,139
b. Unavailable unfinished at refineries	8,957,265
c. In refinery lines and operating equipment.	1,523,393
d. One half of average size water cargo receipt. Total of each individual grade calculated separately	9,993,332
e. Other unavailable stocks	14,776,086
f. Pipe line fill	4,812,521
g. Pipe line operating reserves	6,446,023
h. Unavailable in transit	6,462,372
Total unavailable clean products	75,233,131

Coleman says: "Very little refinery storage has been added since before the war, whereas demand has risen some 50 percent and is of an increasingly variable nature."

President Hope of Esso Standard reports that his company has constructed an additional 1,200,000 barrels of primary storage facilities for the 1949-1950 heating season on the East Coast, and also has increased capacity of a number of bulk plants. Socony-Vacuum Oil Company in the last two years has constructed about 1.5 million barrels of additional storage throughout New England, Delaware and New York.

However, in the judgment of numerous industry experts the construction program is not keeping pace with need. Van Covern, Gray and others argue that the construction of new storage capacity should center at the primary level. At this level storage can be built for about $1.50 per barrel, but at the distributor level the cost rises to $4 to $8 a barrel, while at the consumer level it reaches $12 to $18 a barrel.

The conclusions of WORLD OIL's survey can be summarized as follows:

● Additional heating oil storage at the primary level is needed to assure adequate supplies in case of an unusually severe winter. This job is largely the responsibility of the major oil companies which in a number of cases—but not enough—are meeting the challenge by additional construction. Total primary storage should be expanded by perhaps 15 percent to take care of anticipated increases of demand for home-heating oils over the next three years.

● The distributor level of storage (10,000 barrel tanks and under) is not adequate for anticipated future demand, but investment costs will be a strong deterrent to increasing storage at this level. The independent distributors are highly sensitive to price fluctuations, even to the extent of filling their existing storage in times of unsettled market prices.

● Consumer storage should be increased by about 30 million barrels through standard introduction of the 500-barrel tank in place of the 275-barrel tank. However, progress on this will be slow, especially in communities where larger size tanks are presently prohibited by law.

● Expansion of heating oil storage will indirectly guarantee added gasoline storage, if needed, through the convertibility of all clean-storage tankage from fuel oil to gasoline, at both the primary and secondary levels.

● Added storage facilities can best be placed closer to the consuming areas and farther away from the refineries themselves. In this respect large terminal storage facilities are the most needed type of installation at the present time.

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~~214 Oil & Gas Bldg.,~~
~~Houston, Texas.~~

DATE	DESCRIPTION	HOURS	RATE	AMOUNT
9/20-21/49	Tear Down, move and set-up your Rig from Welder-Mecom #1 to Welder-Mecom #2. Pull water well and haul tool from your rig at Bloomington, to your rig Welder-Mecom #2 and haul tools from your rig to D& W Tool Co. in Victoria.			
	One 20 Ton Tandem W/ Driver & Helper	5	16.25	81.25
	One 8-10 Ton Truck W/ Driver & Helper	3	10.75	32.25
	Two 2½ Ton trucks W/ Drivers & Helpers	29	6.25	181.25
	~~3~~% Federal Tax			8.84
				~~303.59~~

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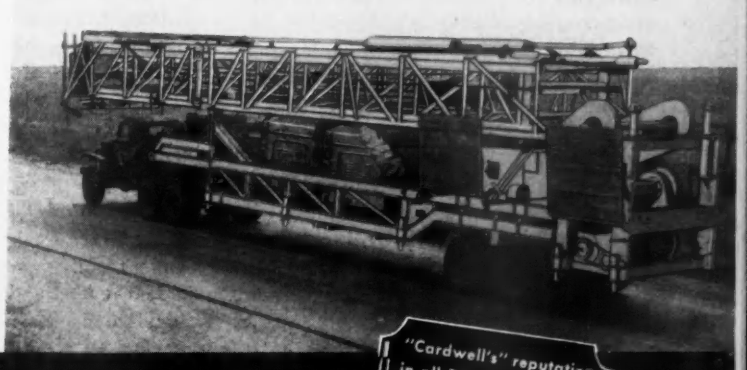

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Financing Oil Properties

By FRED F. FLORENCE
President, The Republic National Bank of Dallas

BANKS IN THE SOUTHWEST, as well as in the East, have found the financing of oil and gas properties good business. Loss records on oil loans have been remarkably low.

Banks make these loans on the basis of analytical and evaluation reports of their engineers, ability and integrity of the operators, and recognition of general economic forces which might affect the loans.

UTILIZATION of banking facilities in a broader sense, to assist oil men in financing and operating oil and/or gas producing properties in the Southwest may properly be dated from the discovery of the East Texas field. At that time the banks in the area were confronted with the problem of either ignoring the requirements of this new type of banking or of facing the issue and accepting their responsibility to assist, along the lines of accepted banking principles, in the development of the Southwest's oil and gas resources by extending adequate lines of credit.

Oil financing by banks, especially those in the East, had been an accepted practice, but it was not until the early 1930's that banks in the Southwest became really interested in this type of financing. With the advent of oil proration it was evident that independent oil operators would turn to the commercial banks of this area for their requirements. With personal knowledge of the ability and integrity of the operators, the commercial banks accepted their responsibilities, and in 1933 the writer's institution, for example, proceeded to make a total of 165 oil loans during the year. Over the past 16 years the same institution has loaned for its own account an aggregate amount well in excess of $300 million, exclusive of large sums loaned and serviced for correspondent banks and other lending institutions. Hence, at this time, the average oil loan on our books amounts to $300,000, and the total of this paper currently comprises about 40 percent of outstanding loans in all classes.

The relation between banking institutions and independent oil men has been a happy one and the writer feels on firm ground when he speaks for other banks, as well as his own, in saying that making oil loans is good business.

In their financial transactions with commercial banks, independent oil men in the Southwest have proved a credit to their industry. While it is true that banks are required by law to conform to certain standard practices in the making of loans in all categories, it is equally evident that oil financing could not possibly have become a popular and profitable line of business for commercial banks if the customer seeking an oil loan had not been a man of sound business judgment and integrity.

Loss Record

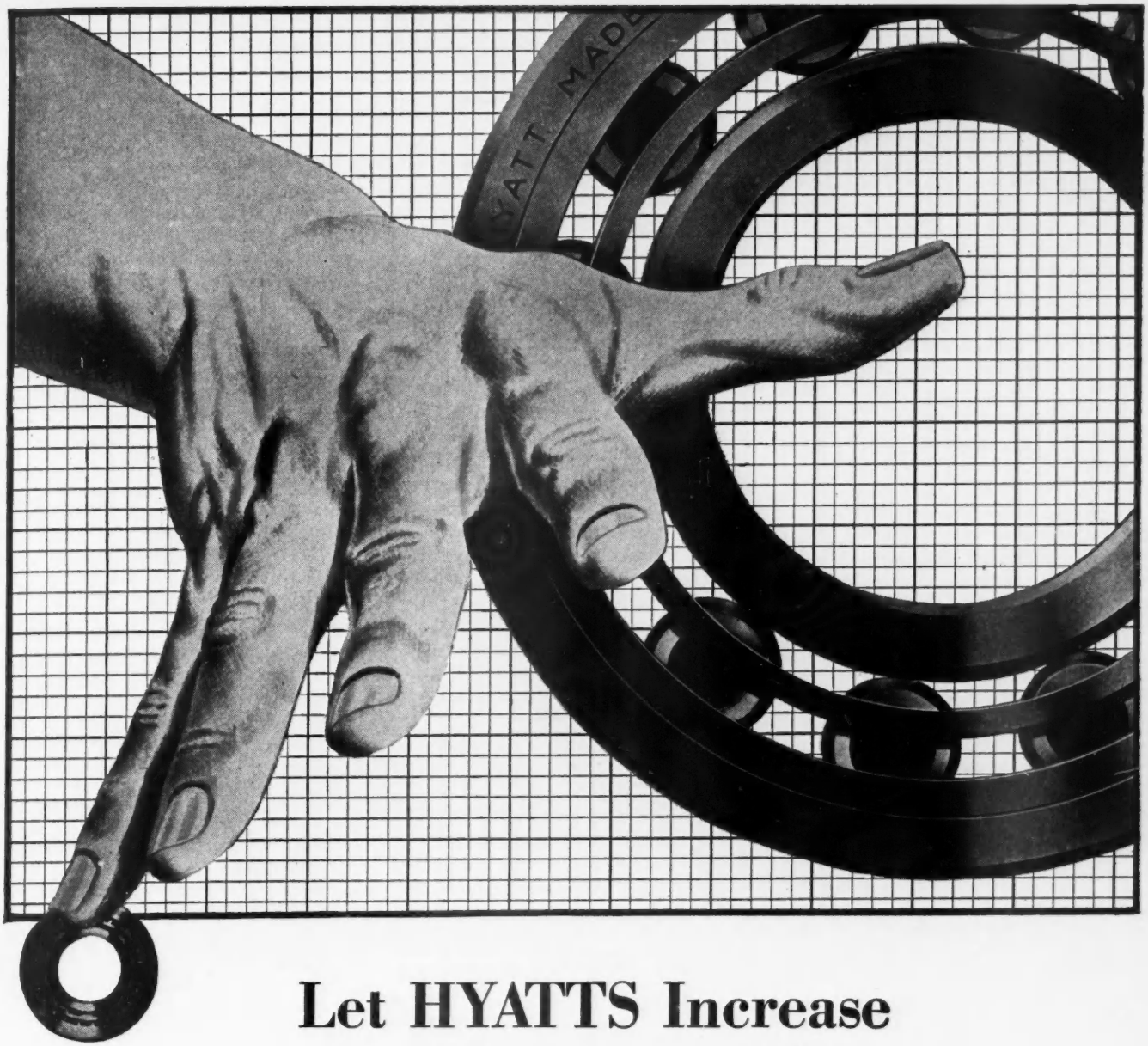
Just how good a customer the independent oil operator has proven is evidenced by this institution's loss record on oil loans. During the past 16 years, net losses in this field have totaled $90,000, a sum substantially less than one month's interest and representing a loss ratio of .03 to 1 percent of the total loans made. While there have been flagrant exceptions to such a favorable record, it is the writer's opinion that this type of financing, when all precautionary measures are taken, has gradually become recognized as a very sound and profitable source of earning power for commercial banks and insurance companies. In recent years the latter, in particular, have demonstrated a keen interest in this type of business.

Lending Procedure

As a matter of consistent approach, banks must rely solely upon the analytical and evaluation reports of their own engineering staffs, although there are cases where it is necessary to obtain independent opinion of consultants who specialize in this field.

There are many scientific and technical factors which must be thoroughly understood and applied to engineering analyses and once they are reduced to the common denominator of present worth, the banker is prepared to judge the credit risk and determine the safety factor and other provisions necessary to the loan.

Three principal methods of scientifically estimating reserves, which, in the financing of oil properties, must be considered the influencing factor, are the volumetric, decline curve, and a combination of both. The decline curve is usually the most accurate, as it is computed with experience from past performance, as contrasted with entertaining a necessarily more cautious attitude toward the frequent whims of new or prorated production. In considering any oil loan, the writer cannot overemphasize the necessity of actual field tests to de-



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termine the productivity and other operating characteristics of the wells in question.

Legal Aspects

The deed of trust and assignment of runs is the instrument under Texas law which is drawn to convey good and merchantable title unto the lending institution or its trustee. After this instrument is filed of record in the county or counties in which the property is located, there is created a first lien on the property and the assignment (generally included in the same instrument) provides that the purchaser of the oil pay the proceeds direct to the lender. The lender then applies these funds, which are received monthly, on the indebtedness of the borrower in accordance with the terms of the loan.

The above instrument also contains the "future advance clause," a legal record of notice to other creditors that the lender may make additional advances in the future on the same collateral and remain in a first lien position. This facilitates additional financing when warranted without further examination of titles and eliminates the necessity of new instruments with their attendant expense. This feature is extremely important, since a substantial percentage of such loans comes under the category of "repeat business."

Market Conditions

To the extent that sound engineering analysis and legal advice are absolute prerequisites, so it is that the ability to interpret them in a practical vein is essential to the consummation of a mutually satisfactory loan. This responsibility is that of the banker who comes in direct contact with the customer, and not infrequently does he have the opportunity of suggesting an amendment to an original proposal which proves no hardship to the borrower and by the same token enables the bank to take on an attractive piece of business which, otherwise, might not be handled. While lending officers rely primarily upon the value of the pledged collateral, they must be constantly alert and attuned to changing economic forces which conceivably might drastically affect the complexion of the loan. During the war years the price of crude oil was frozen, while the wholesale commodity index was constantly rising. After the cessation of hostilities in 1945, with subsequent price relief for the oil operator, oil loans began to increase at a rapid pace. In November, 1947, the price of crude was advanced 50 cents per barrel, thereby establishing a posted price for the desirable East Texas production at $2.65 per barrel. Even so, premiums became widespread for this type and well connections seemed to change overnight. Rumor had it that the posted price would be further increased, perhaps even to $3. It became evident that we were experiencing a postwar adjustment. Crude prices were coming into line with the wholesale commodity index, to which they had reacted sympathetically for the past 20 years. Demand for oil money was heavy and the new price level presented a rather perplexing problem from a lending viewpoint. The oil man could not hedge his position, as done in the commodity markets.

In meeting this situation the writer's institution concluded not to consider the new price increase in determination of basic collateral values. It did, however, give immediate credit for the anticipated increase in production income for a two-year period, thereby somewhat enhancing those values. Curiously enough, with the exception of three or four minor loans with a quick payout, we have had no application to which this conservative formula could not be acceptably applied.

Maturity Factor

It is a generally accepted theory that the longer the maturity, the more possibility of risk. Many unforseen and unfavorable factors may develop with the passage of time. This has often occurred and will occur in the future, and protective covenants in the loan agreement should be drawn against such a contingency. However, in oil financing, presupposing an adequate safety factor, it is not so much the maturity, per se, but the estimated payout which assumes paramount importance. Even with the application of the most conservative lending formula, a 15-year-loan may appear indisputably safe, yet the writer feels that it hardly comes within the bounds of sound commercial banking practice. Nevertheless, bankers must accentuate the fact that they are desirous to arrange such financing and the writer's institution has done so in many instances in conjunction with lending institutions and financial connections more interested in the longer payouts and corresponding maturities. In these cases we take the first maturing installments in conformity without general practice of limiting our payouts to a maximum of five years.

Market Factors

In the past 1½ years the Mid-Continent price for fuel oil dropped from $2.60 to 90 cents per barrel. The gasoline market remained firm and, naturally, the refineries emphasized the output of that "money" product. It would appear that the weakness in fuel oil should have had a rather softening effect on the crude price structure. Yet, excepting the lower gravity crudes, the price remained unchanged despite sizable imports. The action of the regulatory authorities to cut allowables is commendable to the point that without such wisdom the price level would have inevitably declined. The period of high gasoline consumption has passed and refiners are now viewing the residual consuming market with encouragement. As compared with 1948, a considerably larger fourth quarter demand for heating oils is predicted and fuel oil prices have already increased.

All of us have watched with tremendous interest the oil development in Canada, and, there has been much discussion within the industry and at Washington in regard to Venezuela and Saudi Arabia. Assuredly we must be mindful of these great productive sources and their possible effect in the future on our petroleum economy. Economists have fully considered the significance of this "threat," but for the immediate future the supply-demand factor (including current imports) augurs well for a stabilized crude price. The attitude of the average bank on this score is definitely more favorable than for some time past, and while lending institutions, in the writer's opinion, entertain no thought of altering their conservative lending policies, he feels that they will continue to be aggressive in developing this business.

About the Author

FRED F. FLORENCE, president of the Republic National Bank of Dallas, has long been a believer in the development of the great resources of the Southwest. He has been identified with banking since 1907 and since 1920 has been associated with the Republic, serving as president since 1929. In addition to serving as a director of several banks and a number of other business concerns, including the Missouri-Kansas-Texas Railroad of Texas, he is prominently identified with various social, civic, and public welfare activities in Dallas and the nation.

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PACKINGS, GASKETS AND OIL SEALS

The SALT WATER Problem in Texas

By WILLIAM O. GEORGE
Geologist, U. S. Geological Survey

THE main purpose of this discussion is to describe briefly the occurrence of underground water as related to surface-casing requirements in oil wells in Texas. Most Texans are conscious of the importance of water to the continued development of the state, and the regulatory agencies concerned with water supplies therefore receive popular support. The prevention of contamination of fresh water by salt water has become one of the functions of a number of state research and regulatory agencies. These are the Texas Board of Water Engineers; the Game, Fish, and Oyster Commission; the State Health Department; and the Oil and Gas Division of the Railroad Commission. Because of these agencies, the control of the disposal of salt water and other industrial wastes is becoming increasingly effective.

Responsibility for the proper construction of oil wells to prevent contamination of fresh water by salt water from oil wells lies entirely in the hands of the Oil and Gas Division of the Railroad Commission. At present, by mutual agreement, the depths of fresh-water-bearing formations are reported by the Texas Board of Water Engineers, and the methods of protecting the fresh water are prescribed by the Railroad Commission. Upon the request of the operator or driller the Board of Water Engineers states the depth or depths of formations that contain fresh water. The data from the Board of Water Engineers are presented at a hearing of the Commission where they become a part of the data considered in granting or denying production from the well and in making rules for surface-casing requirements.

AN IMPORTANT responsibility rests on the oil industry in preventing contamination of fresh water sands by salt water from oil wells. Underground water as found in Texas is here discussed in relation to surface-casing requirements in wells drilled for oil and gas. Drilling for oil has given much information on fresh water sands and has promoted utilization of water from those sources. This article is published by permission of the director of the U. S. Geological Survey.

For about 20 years, the Texas Board of Water Engineers in cooperation with the U. S. Geological Survey has accumulated and studied data about underground water in Texas so that such water may be conserved and wisely used. The data sought are, mainly, the geologic distribution of water-bearing formations, the transmissibility and storage capacities of ground-water reservoirs, and the chemical character of the water contained in them.

The words "fresh" and "salt" are somewhat vague because there are no practicable definitions for them. In many places in Texas the chemical character of the best water available falls far below the standards of the state and federal public health agencies, which have indicated that 500 parts per million of dissolved solids is the maximum of mineralization desirable for public supplies. What might be called brackish or salty water in Southeast Texas is better than much of the ground water that is used for stock and irrigation in parts of West Texas. The decision as to whether the water is "fresh" or "salty" is, therefore,

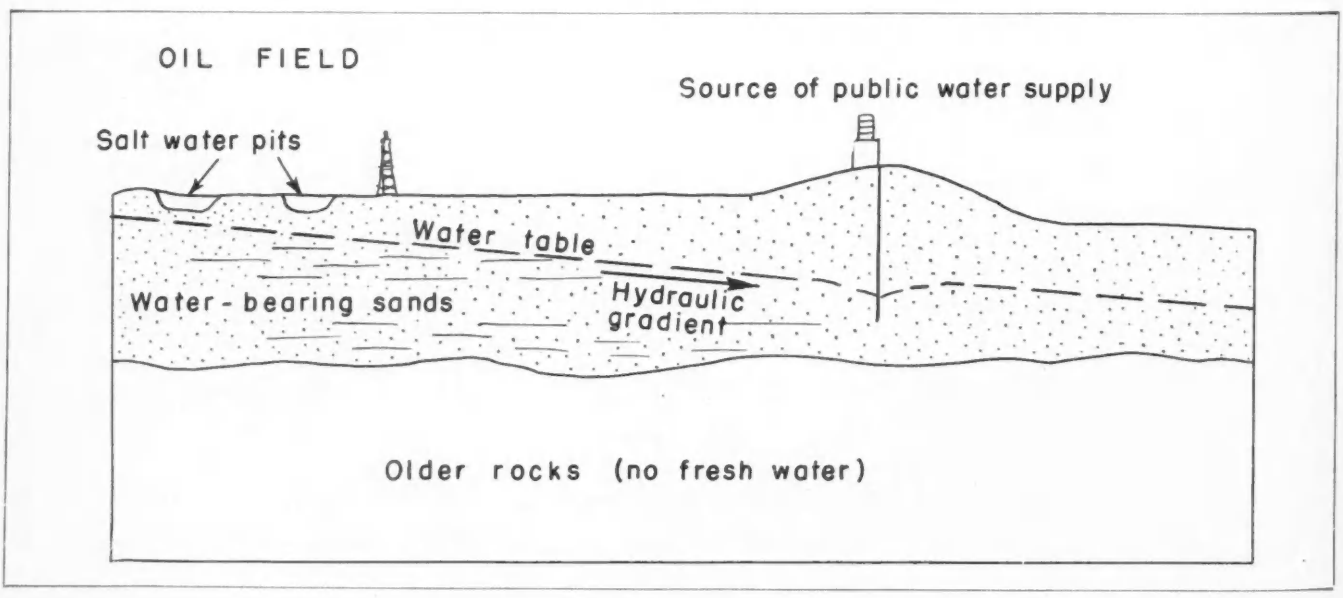

FIGURE 1. Leakage of oil-field brines to water wells.

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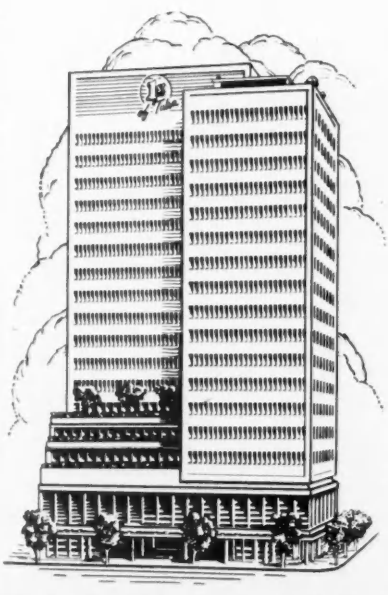

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December 31, 1949

RESOURCES

Cash and Due from Banks	$56,339,216.01	
U. S. Government Securities	85,389,289.52	$141,728,505.53
Other Bonds and Securities		7,828,907.97
Loans and Discounts		49,722,253.81
Federal Reserve Bank Stock		240,000.00
Income Earned, Not Collected		348,584.95
Future Banking Quarters		1.00
Equipment—New Banking Quarters		54,930.17
Furniture and Fixtures		1.00
Customers' Liability Under Letters of Credit		25,000.00
Other Resources		16,024.80
		$199,964,209.23

LIABILITIES

Deposits		$188,714,813.65
Income Collected, Not Earned		288,114.77
Taxes, Interest and Expense—Accrued		575,843.62
Letters of Credit Outstanding		25,000.00
Capital	$3,000,000.00	
Surplus	5,000,000.00	
Undivided Profits	2,360,437.19	10,360,437.19
		$199,964,209.23

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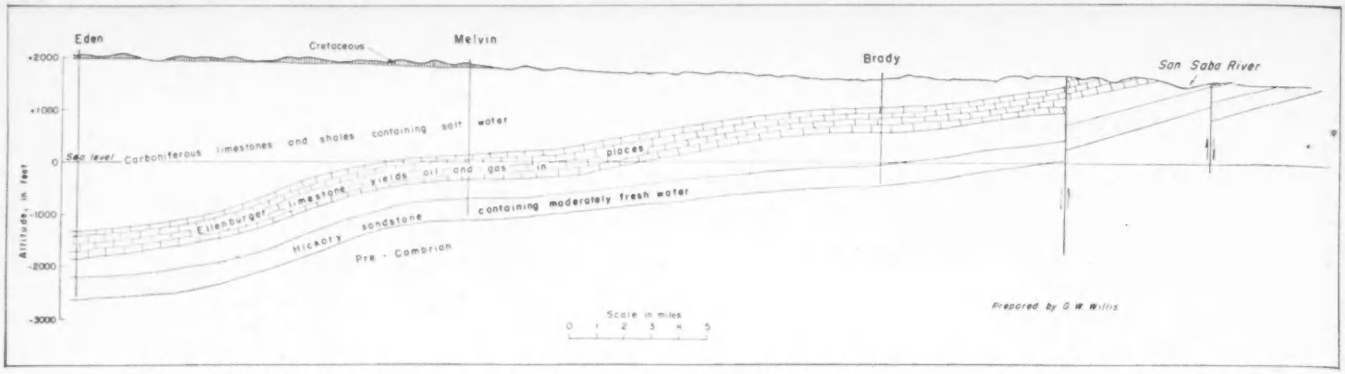

FIGURE 2. Generalized geologic section from Concho County to San Saba County, Texas.

arbitrary and depends somewhat on the amount and kind of water available in the area where the oil well is to be drilled.

Water used for public supplies in Texas is found at depths ranging from 10 to about 4200 feet. It is found under water-table conditions where the reservoir is supplied by direct penetration of rainfall, and under artesian conditions where the water moves downdip under cover of relatively impermeable beds, and where it rises to levels above the depth at which it is encountered in wells.

Water-table reservoirs are seldom contaminated by direct leakage from oil wells. The contamination of water-table reservoirs comes largely from leaky earthen pits that store salt water from separation tanks after it leaves the oil well. The salt water is stored until heavy rains provide enough dilution for release into streams.

Contamination from leaky pits may be serious, particularly if the pit is on sandy land, and if the water-table reservoir is the only source of good water in the area. The salt water moves out into the reservoir very slowly and may not be detected until after the damage is done (Figure 1).

During the early history of Burkburnett, one of the oldest oil towns in Texas, most of the residents had their own private water wells drilled into shallow sands below an alluvial terrace on which the town is situated. Salt water from separation tanks on town lots was discharged into small ravines leading to the river. One by one, the water in the private wells became salty. The public supply is obtained from the same formation about a mile from town. The salt water front is moving slowly toward the public supply, but it may be many years before the present waterworks will have to be abandoned.

Under artesian conditions, ground water generally becomes increasingly mineralized with depth because it dissolves the minerals in the reservoir rocks as it moves downdip. Unfortunately, the degree of mineralization at any given depth cannot be predicted on this basis. Contrary to popular belief, the presence of salt water in a well is not an indication that all the water-bearing formations below will contain salty water. Salt water, oil, and gas may be found above, below, or in the formation containing potable water. In the Winter Garden of South Texas thousands of acres of vegetables are irrigated with water from the Carrizo sand, which lies just below the highly mineralized water in the Bigford member of the Mount Selman formation.

Eden, Texas, (Figure 2), is supplied with water from the Hickory sandstone, Cambrian age, at a depth of about 4200 feet. For many years Eden was supplied with "seep" water from shallow wells that failed during droughts. The deep water sand was found in an oil test that gave the town both natural gas and water. The gas is produced from strata above the water sand.

The Edwards limestone is the source of water for Comal Springs at New Braunfels and many other springs along the Balcones fault zone and for the famous artesian water wells in San Antonio. It also supplies oil to the Lockhart and Luling oil fields, where the oil is associated with salt water.

Movement of Fluids

Natural hydraulic pressures and the relative permeability of the formations control the movement of fluids in open wells. Water will move from a sand having a high pressure to one having a lower pressure, and assuming that the formations are fully exposed in the wells, the rate of movement will be directly proportional to the difference in head and transmissibility of the sands. Thus, artesian aquifers that are heavily pumped, such as those in the Houston district, become increasingly vulnerable as artesian pressures decline.

Blowouts of gas wells into water sands that are not properly cased may produce spectacular and disastrous results, such as occurred in the Bammel field, Harris County, in 1942.

Although it affords little consolation to the operator who drills a dry hole, a tremendous amount of ground-water information is obtained from wildcats that are otherwise failures. Many of these wells are converted to water wells on farms and ranches.

For the state as a whole a tremendous amount of ground-water data has been collected by the Board of Water Engineers and the U. S. Geological Survey. However, there are many localities in Texas in which little or nothing is known about the depth of water-bearing strata or the quality of water contained in them. Some of the requests from oil producers for depths to which ground water should be protected cannot be accurately answered from the information at hand, and decisions are based on electric logs furnished by the operators. This is especially true in areas where plenty of ground water for current needs is available from relatively shallow wells and the deeper water sands have not been explored by the water consumers.

The cooperation between the oil companies and the Texas Board of Water Engineers in the exchange of groundwater information has been more than gratifying. In a few areas oil companies have been asked to furnish evidence in the form of electric logs that reveal relatively deep water sands, and the resulting surface-casing requirements are very costly. The regulation may seem especially harsh in view of the fact that the chemical character of the water in a formation is based on the interpretation of electric logs, which in some cases may not indicate whether or not water in a formation is definitely "fresh" or "brackish." In such cases the benefit of the doubt is generally given to the oil operator. The apparent injustice of asking oil operators to furnish evidence that may be used to their disadvantage is tempered somewhat by the fact that fresh water is also important to the oil industry as a whole, for its continued prosperity depends upon the welfare of its customers, who are also water consumers.

Sholem Alechem Pool

Presents Complex Geological Picture

By HAROLD R. BILLINGSLEY

The Atlantic Refining Company, Shawnee, Okla.

SHOLEM ALECHEM field of southern Oklahoma, nine miles long and ranging up to two miles in width, now is the second largest oil producing pool in Oklahoma. Although it produced only 706,853 barrels in 1947, output jumped to 5 million barrels in 1948, following discovery and development of the deeper Springer production.

ALTHOUGH Southern Oklahoma geology has received considerable study, little is actually known regarding subsurface details of local geologic structures, such as the Sholem Alechem anticline, which extends from Sect. 11-2s-3w, in Carter County, northwestward into Sect. 34-1n-4w, in Stephens County (Figure 1). Surface expression of this field is a northwest-southeast trending anticlinal ridge with 200 to 300 feet of relief.

The Sholem Alechem field, which is approximately nine miles long and more than two miles across its maximum width, is the second largest oil producer in Oklahoma. Prior to August, 1947, the field played a minor role. However, the discovery and subsequent development of the deeper Springer production has increased the total yearly production of the field from 706,853 barrels in 1947, to approximately 5 million barrels in 1948.

The field was discovered in December, 1923, by Humble Oil & Refining Company's Jennings 1, SW SW SW 28-1s-3w, one of the few standard tool wells drilled in the field, for initial production of 90 barrels on pump from a Deese sand. Development progressed slowly through the 1920's and drilling came to a virtual standstill in the 1930's. Production was entirely from lenticular sandstones in the Hoxbar and Deese formations until August, 1947, when Stanolind Oil and Gas Company tapped production in the Springer sand at its Sims 1, NE NE SE 2-1s-4w. While initial potential of this well was not spectacular, subsequent tests in the area reveal a considerable extent and thickness of sandstone and indicate the field to be one of the most important oil reserves to be opened up so far in the Ardmore basin.

Stratigraphic and Structural History

The Sholem Alechem anticline is near the axis of a northwest-southeast trending depositional trough termed the Anadarko-Ardmore geosyncline. This geosyncline subsided steadily from Cambrian to early Pennsylvanian time, resulting in the deposition of great thicknesses of sediments.

The extent of Cambrian sediments is imperfectly known in this area, because relatively few wells have penetrated so deeply; however, their presence and thickness in the Arbuckle and Wichita mountains suggests that they are present under most of the area. Pre-Pennsylvanian sediments in this region consist mainly of vast thicknesses of limestones. The Arbuckle limestone of Cambro-Ordovician age and the Viola limestone of Ordovician age suggest either deep sea deposition or continuous precipitation from rising shallow seas, while the Sylvan shale, with a thickness of about 300 feet, is indicative of quiet and stable depositional conditions during late Ordovician time. Siluro-Devonian deposition, that is, the Hunton group, in this region consists of about 500 feet of limestones. Early Mississippian (Woodford) shale and the Sycamore limestone account for the remainder of the Pre-Pennsylvanian geologic section.

Lower Pennsylvanian and upper Mississippian deposits in this area have been described as orogenic deposits, resulting from the early Wichita orogeny. However, in the Sholem Alechem field, there is no evidence to indicate that any important mountain-making movements occurred prior to late Springer time. In fact, the remarkable similarity between the Caney shale of Mississippian age and the Springer shale of Pennsylvanian age suggests that, in this vicinity at least, deposition continued without any interruption other than possible changes in depth conditions necessary to produce the slight differences noted in these sediments.

This suggests that even though the early Wichita orogeny might have caused the seas to retreat from north central Oklahoma at the close of Mississippian time, the basin areas of southern Oklahoma remained submerged. Sandstone zones found in the Springer shale sequence might reasonably be interpreted as indicating a change from deep to shallow water conditions caused by oscillations of this retreating sea. Of these zones, the Sims sandstone is the most important as a commercial producer of oil. Since its discovery in 1947, this zone has been the object of most exploratory wells drilled in the northwest part of the field. Thickness maps indicate a marked thickening in a northeasterly direction, with the best development appearing on the northeast flank of the structure. Since the thickness does not reflect the structure of the field, it may be inferred that the anticlinal structure was not present at the time during which the Sims sandstone was being deposited.

Although some production is currently being found on the south flank, the most favorable part of the structure for future production from this sandstone zone appears to be the north flank. It is believed that the Sims zone will be found to be poorly developed over much of the southeastern part of the field and on the lower part of the south flank of the northwest part of the field, with commercial production of oil and gas improbable.

Unnamed sandstones, above the Sims and near the top of the Springer section, dip steeply to the east. These sandstones are truncated on the east flank of the structure by the post-Springer unconformity. Since repeated tests have proven them to contain only water, it is logical to assume that, if oil was ever present in these rocks, it probably escaped during the period of erosion which caused their truncation.

The post-Morrowan main Wichita

orogeny marked the close of lower Pennsylvanian time. This uplift is thought to be the movement which initiated the retreat of the Springer seas; exposing the high areas to a period of erosion and producing the post-Springer unconformity recognized in Sholem Alechem and other fields in the area.

Although the readvance of the seas in Dornick Hills time did not reach north central Oklahoma, most of the basin areas of southern Oklahoma were covered. The crest of the Sholem Alechem anticline, however, evidently was not submerged, but remained exposed to continuous erosion throughout Dornick Hills time. This may account for the absence of Dornick Hills sediments in the field, which, if substantiated, indicates that the initial folding of the structure might have occurred as early as late Springer time.

The retreat of the seas again at the close of Dornick Hills time was followed by a widespread readvance in Deese time, resulting in complete submergence of much of the Mid-Continent region. Deposition of sediments of a mixed lithologic character on the unconformable surface of Mississippian rocks in north central Oklahoma and on the unconformable surface of the Springer in this field, followed. From this, it would appear reasonable to assume that although it represents a longer period of emergence and erosion, the post-Mississippian pre-Deese unconformity, so widely recognized in north central Oklahoma, is in part equivalent to the post-Springer pre-Deese unconformity recognized in the Sholem Alechem field.

Unstable conditions during Deese time are strongly suggested by the character of the Deese sediments deposited in this area. Thin limestone beds, lenticular sandstones, micaceous shales and arkosic lenses all indicate

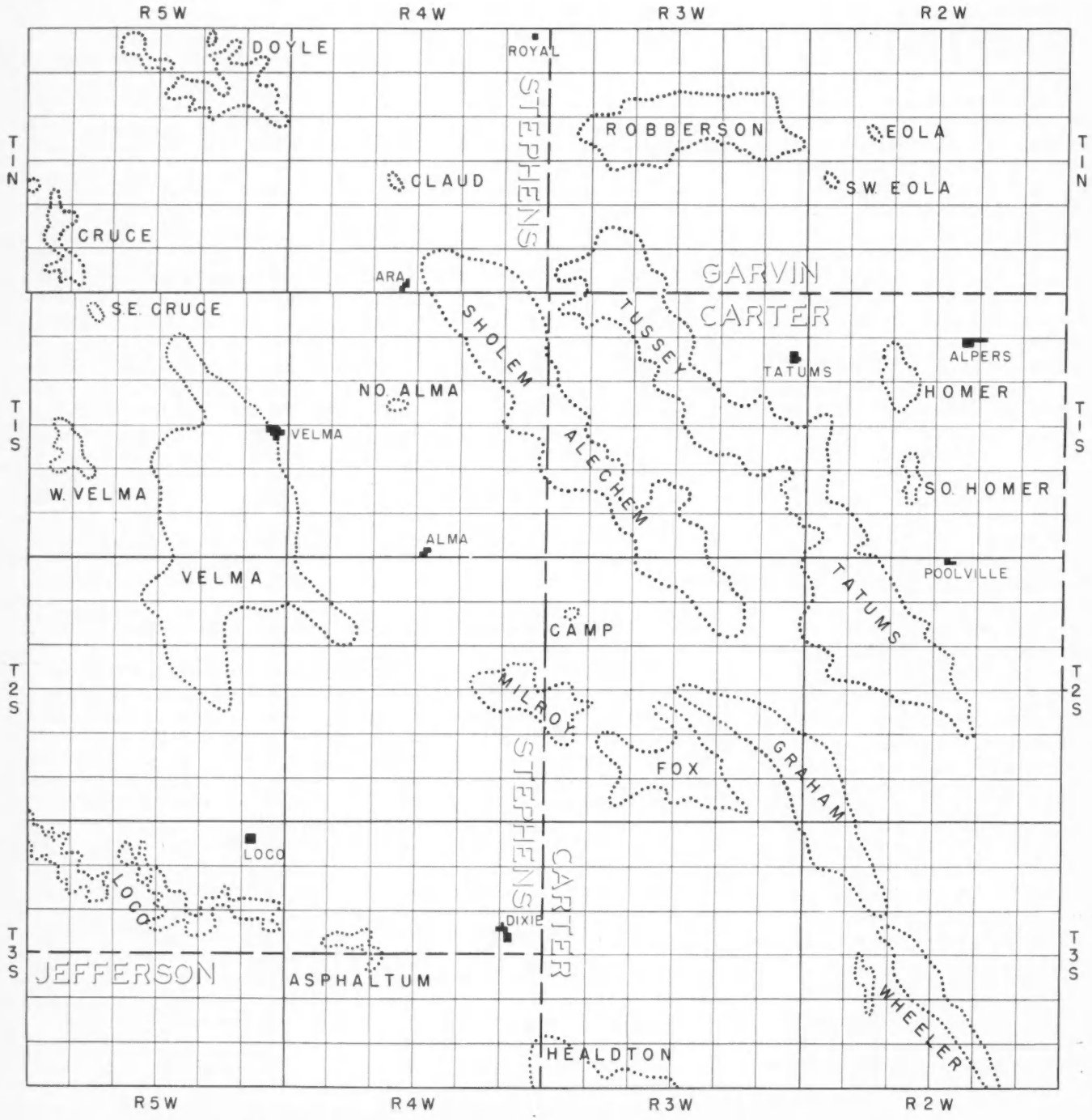

FIGURE 1. Location map of Sholem Alechem pool and other Southern Oklahoma oil fields.

fluctuating sea levels and constantly changing depositional conditions.

Conditions of emergence and erosion are again indicated at the close of Deese time by the disconformable relationships of the Deese and the overlying County Line limestone of Hoxbar age. The character of this limestone implies a restricted reef facies of local limestone deposition because it is best developed on the crest of the structure.

Intermittent movements within the Hoxbar sequence culminated toward the end of Pennsylvanian time in the Arbuckle orogeny, during which local structures within the Anadarko-Ardmore geosyncline were folded and faulted by thrusting from the south, and were in turn eroded. The Cisco formation, representing the derived material resulting from this orogeny, was deposited on the flanks of the structures. Although the main Wichita orogeny of post-Springer time may have caused the initial folding, it was during the Arbuckle orogeny of late Pennsylvanian time that the principal and final folding of the Sholem Alechem anticline occurred. Associated thrusting from the south at this time probably caused the steep dips noted on this and other local structures in the area.

Termination of this orogeny marked the beginning of Permian time, followed by a period of erosion and removal of great thicknesses of sediments from the crests of the structures and the consequent redeposition of the Pontotoc conglomerate. In Sholem Alechem and surrounding fields, this formation is a fine, sandy and cherty conglomeratic formation representing an interval of in-

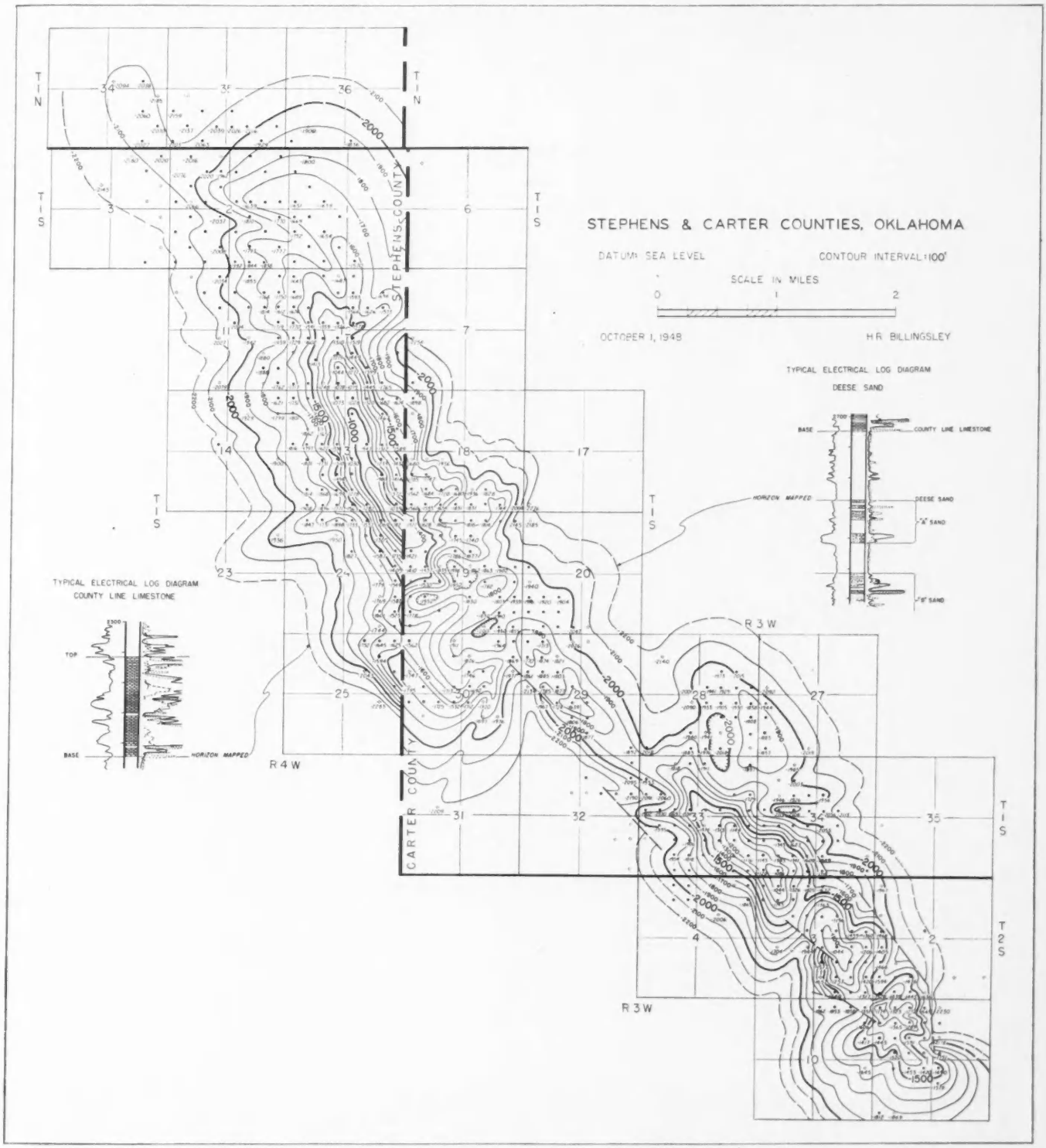

FIGURE 2. Structural map of Sholem Alechem oil field, Stephens and Carter counties, Oklahoma. (Datum — base of County Line limestone and Deese sand.)

tense erosion. The advance of shallow Permian seas followed, marking the beginning of the Wichita-Clearfork deposition of red beds, which, over the field, are remarkably consistent in thickness.

During and after the deposition of the Permian sediments in this region, diastrophic movements were limited to gentle folding, arching the Pontotoc and Wichita-Clearfork cover in this field above the shallow seas.

In the Pennsylvanian stratigraphy of southern Oklahoma, each field appears to have its own stratigraphic sequence. The lensing nature and lateral lithologic variations of the beds makes correlations between fields and even between offset wells difficult or, as in many cases, virtually impossible. However, zonal characteristics are, in general, fairly persistent, and regional correlations can be made to some degree of satisfaction once local standards have been established.

Surface rocks in the vicinity of the Sholem Alechem field consist of Permian Wichita-Clearfork sandstones and mudstone conglomerates. These surface beds have a regional dip of about 30 feet per mile towards the northeast into the Anadarko basin.

Progressing downward from the surface, the drill penetrates approximately 1000 feet of the Wichita-Clearfork formation. Beneath this formation lie the Pontotoc red beds, the basal 250 to 300 feet of which is represented by a conglomerate of coarse sand, divitrified chert and arkosic gravels.

Cisco Formation. The Virgilian series is

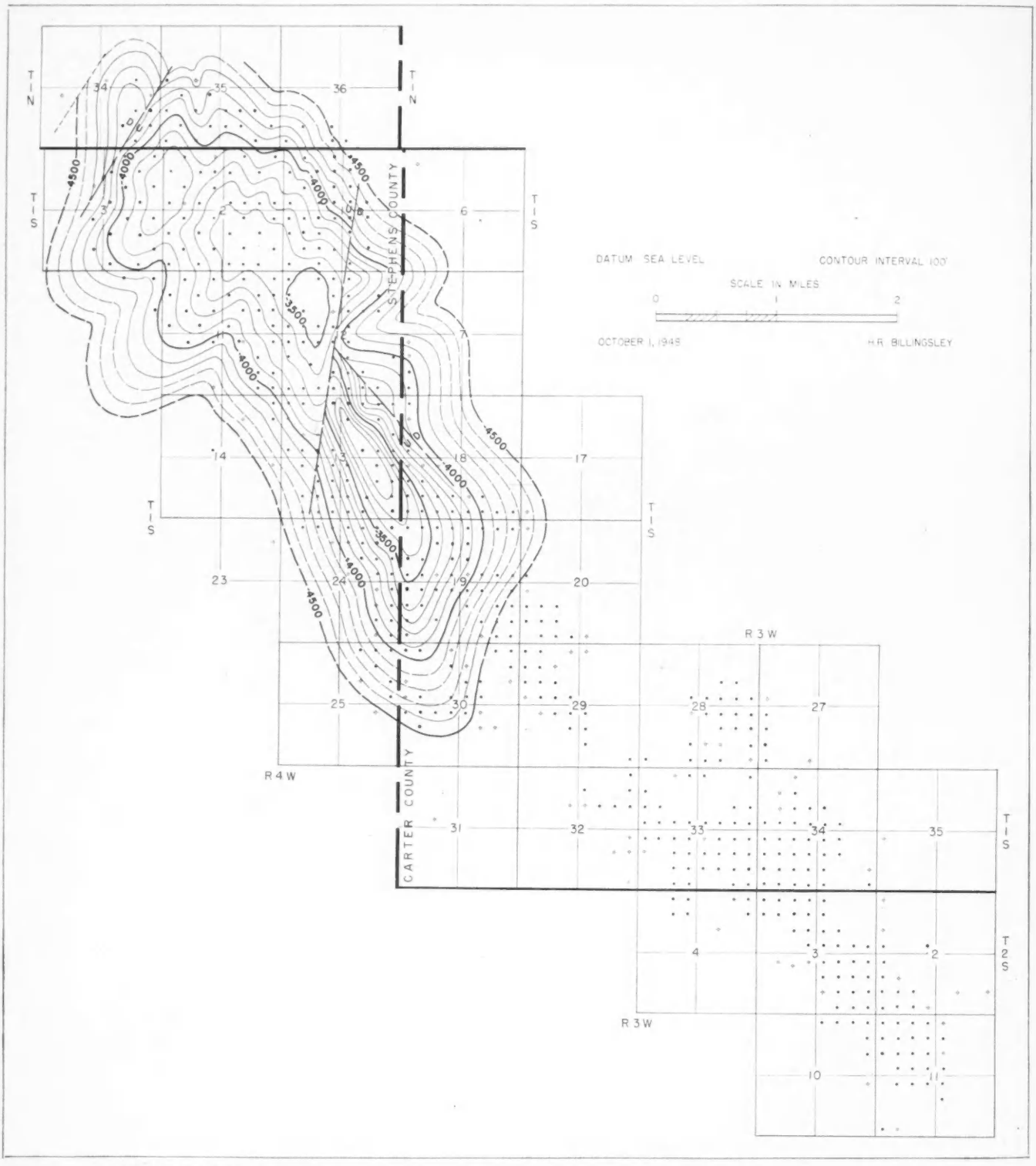

FIGURE 3. Sholem Alechem is an anticline with a northwest-southeast axis. (Datum—top Sims Sandstone zone.)

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represented by the Cisco formation in Sholem Alechem. This formation is made up of coarse grained sandstones, clastic limestones and red shales. In this field, as in surrounding fields, the Cisco formation is extremely difficult to recognize in well samples and is usually included within the overlying Pontotoc group.

Hoxbar Formation. Missourian strata are represented by the Hoxbar formation. In this field these sediments vary in thickness from 200 to 800 feet and lie disconformably below the coarse clastic sediments of the Cisco formation. The Hoxbar sediments consist of gray carbonaceous shales at the top, intercalated with thin beds of porous sandstones, some of which are slightly calcareous. In Sholem Alechem, the County Line limestone makes up the greater part of the Hoxbar sequence, varying from 300 to 500 feet in thickness. This limestone is massive-bedded, chalky to slightly granular; being best developed along the crest of the structure. Locally it carries shows of oil and gas.

Deese Formation. The Deese or Desmoinesian section has a maximum thickness of 8000 feet in the Ardmore basin. However, in Sholem Alechem it is relatively thin. It is made up mainly of gray, micaceous shales, lenticular sandstones and thin limestone streaks. Two important sandstone zones are included within this section; the "A" or Sholem Alechem sand zone and the "B" or Tussy sand zone. These zones are important as producing horizons. Included within the "B" zone is the Tussy limestone. This limestone is thin but fairly persistent and is widely recognizable as a marker bed, both from drill cuttings and from its characteristic curves on the resistivity diagram of the electrical log.

Dornick Hills. In the Ardmore basin, the Dornick Hills formation is 2800 feet thick and is upper Morrowan and Atokan in age. These sediments comprise a sequence of clastic limestones, shaly sandstones and gray papery shales similar to those found in the Springer. In Sholem Alechem, however, this entire sequence is absent and Deese sediments rest unconformably upon the Springer.

Springer Formation. In the Ardmore basin, the Springer consists of about 3000 feet of dark gray to brown sideritic shales containing four conspicuous sandstone members. At Sholem Alechem this section is made up of shales with four or five irregular sandstone zones. The Unnamed sandstone, which is found on the east flank of the field dipping steeply to the east; the Humphries sandstone zone, which is very lenticular in character; the First and Second Sims sandstone zones and finally, the Goodwin sand zone. These sandstones all vary in thickness somewhat over the field, but are fairly consistent, with the exception of the Humphries zone. This sandstone varies so radically that it is known to lense out completely between wells.

In the Sholem Alechem field, the section below the Goodwin zone is as yet unexplored except in two wells, the Stanolind 1 Sims, NE NE SE 2-1s-4w, and the Amerada 10 Hanson, SW NW SW 12-1s-4w. These wells penetrated about 1500 feet of Springer shales below the Goodwin sand zone and encountered a black bituminous, Caney-type shale. Although this shale resembles the Caney as to lithological and electrical log characteristics, it cannot be conclusively proven to be Caney shale at this writing.

Although rocks below the Pennsylvanian sequence of Springer shales and sandstones have not been penetrated by the drill in the Sholem Alechem field, there is no reason to doubt that a thick and complete sequence of pre-Pennsylvanian rocks is present at greater depths since this field is located approximately on the axis of the deep Anadarko-Ardmore geosyncline.

Structure of Sholem Alechem

Sholem Alechem is an anticline with a northwest-southeast axis extending from Sect. 34-1m-4w to Sect. 11-2s-3w (Figure 2). This anticline differs from the "buried hill" type of structure found at Healdton and Hewitt in that it is a closely compressed fold in the Pennsylvanian sediments and can be noted to have steeper dips on the north flank.

Repeated studies have indicated that the crest of the structure occurs in Sects. 13 and 24-1s-4w, and appears to shift toward the southwest with depth. The maximum structural closure is mapped on the Sims sandstone zone. While this closure decreases somewhat in higher strata, the structure is reflected sharply in the County Line limestone of Hoxbar age (Figures 2 and 3), and is apparent in the Permian rocks at the surface.

In this compressional type of structure, faulting is an important factor in subsurface structural interpretation. Previously the problem of arriving at a sound picture of the faulting within the Springer sequence of this anticline has given rise to many structural interpretations involving very complex fault patterns. Recent studies, however, have revealed that almost all of these faults occur within the Sims zone, thus suggesting that the variations are not due to faulting as previously believed but are due to incipient erosion and channeling by shore currents during and after the deposition of the sands.

The faults shown in Figure 3 indicate: (1) abrupt changes in dip; (2) marked differences in fluid levels, and (3) marked differences in water-oil and gas-oil contacts. It is suggested that assumed faults which do not satisfy these conditions either do not exist or do not noticeably affect the structural interpretation.

Production

The steep anticlinal structure, which controls the accumulation of oil, is sharply reflected in both shallow and deep beds. Reservoir rocks are principally sandstones in the Hoxbar, Deese and Springer formations. Gas-oil ratios are very erratic; varying from as low as 40:1 to as high as 10,000:1. The gravity of the oil produced averages around 30 degrees API having little or no relation to the structure. Most of the wells in the field have been drilled through the producing zone with rotary tools, casing set, and the zone perforated. Nearly all of the wells at present are pumping wells. More than 150 wells produce from the Springer alone.

ACKNOWLEDGMENT

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About the Author

HAROLD R. BILLINGSLEY was reared in Seminole, Okla., during the boom town days of the Seminole oil field discovery. A student of civil engineering for 3½ years at the University of Oklahoma, he left school in 1941 to be employed in the Engineer and Construction section at Aberdeen Proving Ground, Maryland. In July, 1943, he entered the Army Corps of Engineers and spent three years in the Army, 2½ years of this time as a map editor, draftsman, geodetic computor, and aerial photographer interpretator with a topographic batallion in the European theater. Billingsley reentered Oklahoma University to study geology and in June, 1948, completed work for a B.S. degree. He is now employed by the Atlantic Refining Company, Geological Exploration department, Shawnee, Okla.

Seismic Problems in *Reef Shooting*

By NEAL CLAYTON

Republic Exploration Company, Tulsa

THE North Snyder Area, largest thus far of several areas of Canyon reef production in Scurry County, Texas, was discovered in November, 1948, by Standard Oil Company of Texas, Brown 1-2, in Sect. 440, H. & T. C. R. R., Block 97. Since that time the area has been widely discussed by oil men interested in West Texas.

Development of North Snyder proceeded on a conservative stepout basis until April, 1949, when Sunray, et al., completed R. B. Brown 1 in Sect. 20, J. P. Smith Survey, Block 1. This well topped the reef only 100 feet lower than the discovery, about three miles to the north. A subsequent lease and royalty play resulted in some proven royalties selling for as much as $2500 an acre.

DIFFICULT PROBLEMS involved in mapping reefs by means of reflection seismograph shooting are here pointed out. The discussion is based on work done in correlating seismic reflections with geology in the North Snyder field, largest so far of several areas of Canyon reef production in Scurry County, West Texas. This article was prepared exclusively for WORLD OIL from a slide talk presented before the Dallas Regional Meeting, Society of Exploration Geophysicists, November 17-18, 1949.

Figure 1 shows the relationship of North Snyder to other nearby producing fields in Scurry County. With the exception of Sharon Ridge in the lower left hand corner, all fields are producing from Canyon limestone of middle Pennsylvanian age.

Geologists still are undecided as to whether these Canyon fields represent a chain of reefs or merely local "buildups" on a single large reef mass. Another question, still unanswered, is whether the reefing occurs only in the Canyon or extends downward into the Strawn. To date, the only Strawn producers are east

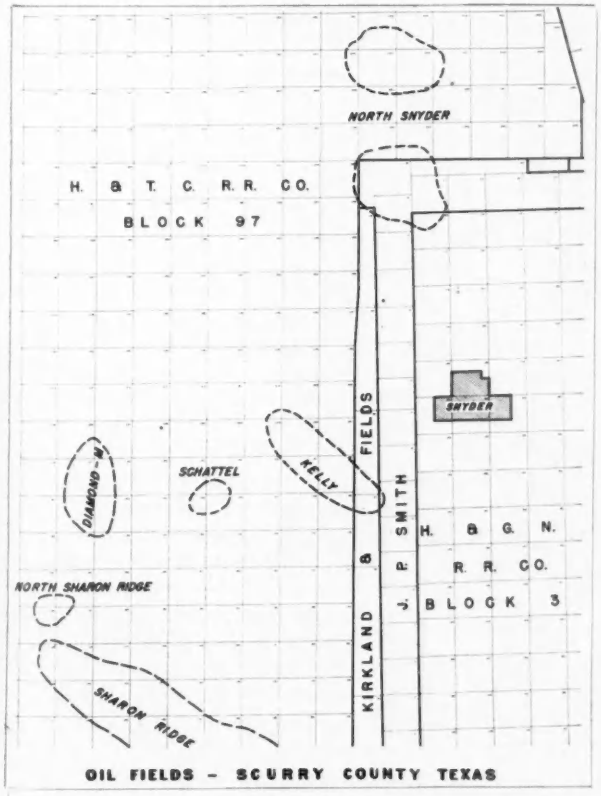


FIGURE 1

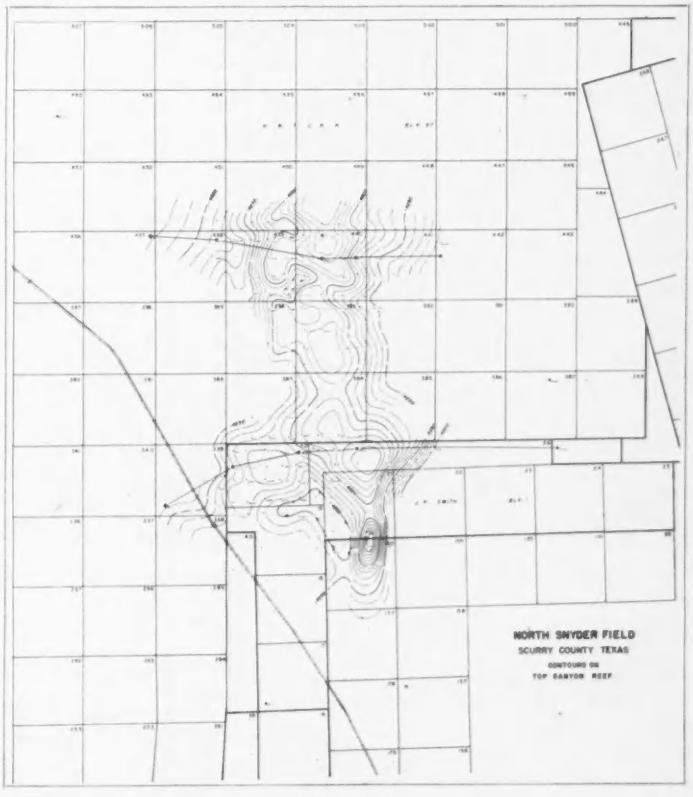


FIGURE 2

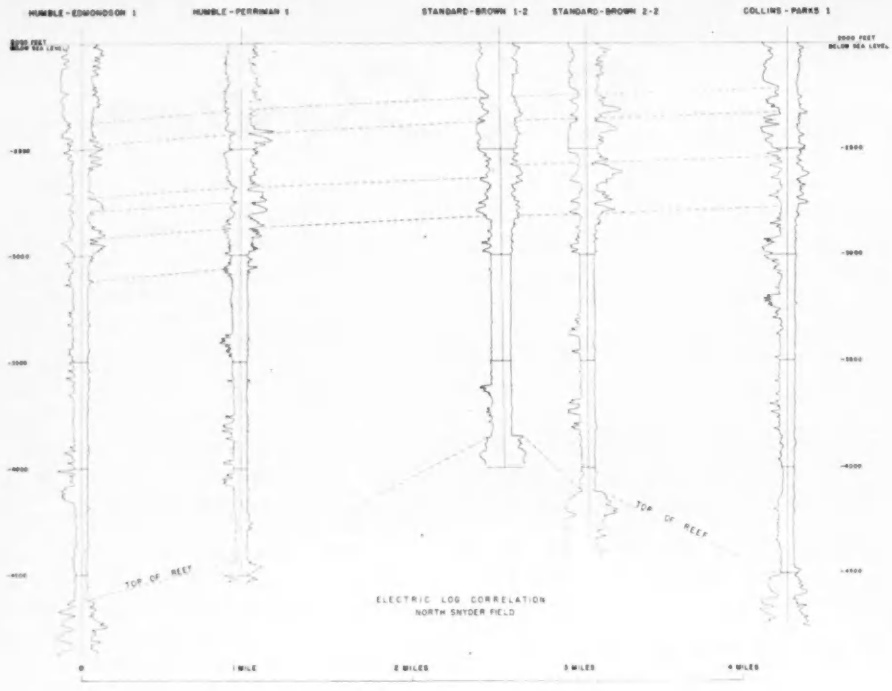


FIGURE 3

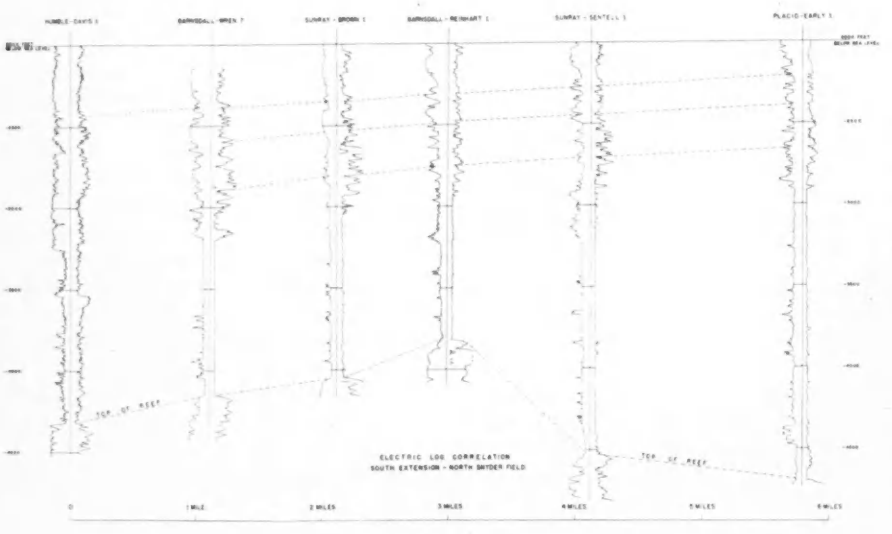


FIGURE 4

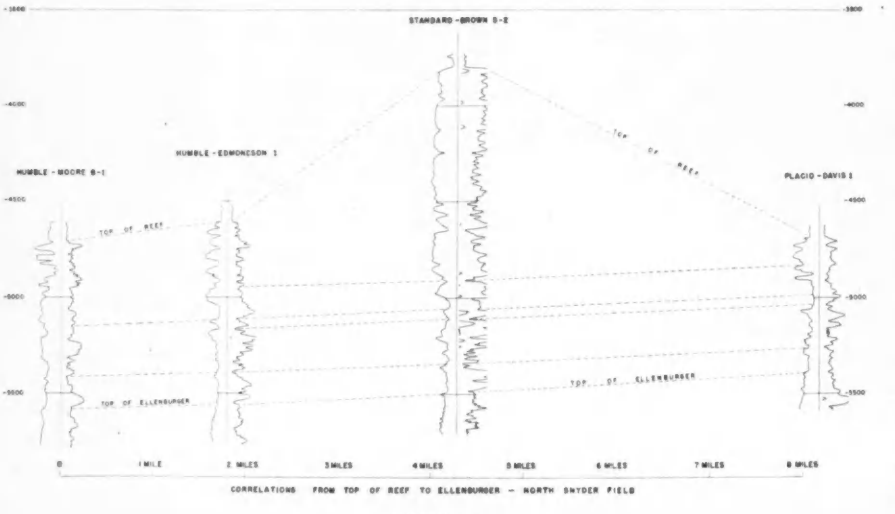


FIGURE 5

of Canyon production at North Snyder.

A contour map on the top of the reef based on well control is shown in Figure 2. It should be noted that the original North Snyder field is very steep on both the east and west flanks, whereas the south extension thus far has exhibited this only on the east flank. The most recent extension resulted from completion of Moncrief et al., Huckabee 1 in NE NW Sect. 160, H. & G. N. R. R., Block 3. The east offset to this well caused a flurry of excitement by topping the reef at —3750, thus becoming the highest well in the entire area. Further development proved this feature to be merely a very sharp peak, however.

In order to illustrate the geology of the area, several electric log cross-sections were prepared. Figure 3 shows a series of correlations made from a point near the base of the Coleman Junction limestone to the top of the reef across the original North Snyder field. Although correlations within the Permian are more difficult here than across the south part of the field, it is believed that little or no relief is present above the reef mass, at least as far as the top of the shale section.

South Extension

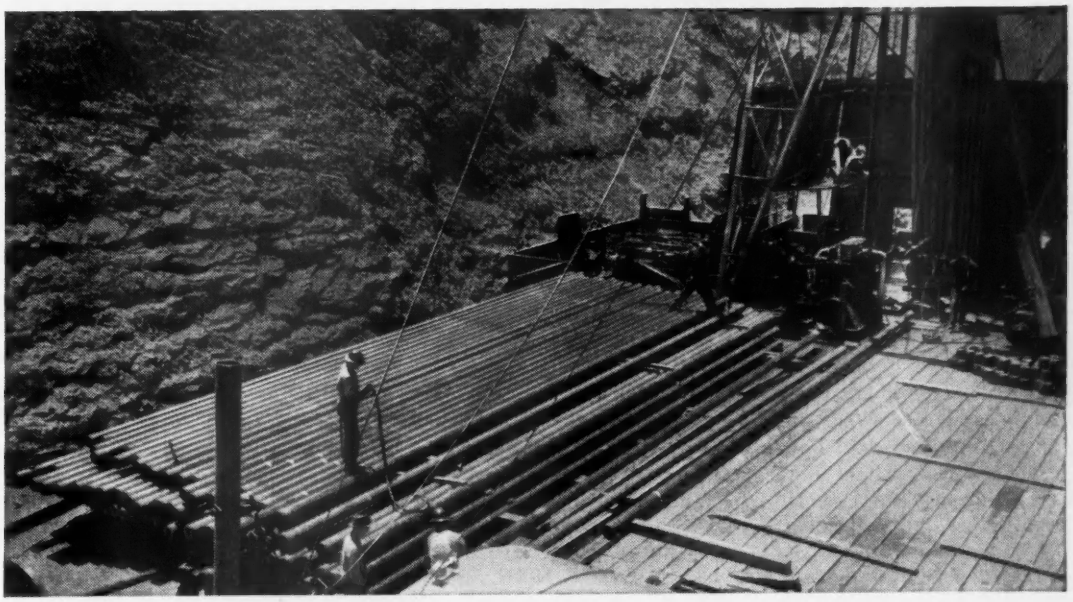
Figure 4 represents a similar series of correlations across the south extension area. Here the correlations are definite, and no structural relief appears to be present above the top of the Pennsylvanian shale section. Recent development near the Moncrief well in Sect. 160 indicates some closure may be present over the sharp feature present.

The relationship of the section between the top of the reef and the Ellenburger across the original field is shown in Figure 5. The Ellenburger appears to be normal although some of the correlations in the Strawn section may be open to question. Since only one well in this field was carried to the Ellenburger, the possibility of local structure cannot be entirely discounted.

In attempting to apply the reflection seismograph to such an area as North Snyder, certain differences should be noted between this type of reef and most of the previous reef discoveries in West Texas. In the first place, North Snyder differs from other reefs, such as Jameson, Vealmoor, etc., in that no structural relief of any consequence is present in the shallow beds. With a few exceptions, most of the recent reef discoveries were found indirectly by the reflection method by mapping structure in beds above the reef mass. A few were located by means of velocity "highs" where beds below the reef could be followed continuously. In practically all of these cases, no recognizable reflection was obtained from the reef itself.

Due to the nature of the geologic

DEPENDABILITY THROUGH



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problem at North Snyder, one must either be able to obtain a reflection from the reef-shale contact or to follow markers below the reef. Since few persistent deep reflections are obtained in this area, the problem becomes one of identifying and following a "reef" reflection, provided, of course, such an event exists. The author is convinced that, at least over most of the south extension area, a reflection is obtained from the top of the reef at North Snyder. No general conclusion can be drawn, however, since all of our work has been done in and around the south part of the field.

The most persistent event recorded in the area is obtained from a point near the base of the Permian lime section. In attempting to identify the reflection from the reef, this event must be used as a point of reference. Beginning at a well where the amount of section between the base of the Permian limestone and the reef is known, identification of the reef event may be made. It is assumed that velocity information is available with which to do this.

In attempting to carry a survey from a known point into areas where no well control is available, the interpreter is faced with a most difficult problem. Surface conditions, such as a change from shale to caliche, impair record quality which, in turn, makes identification of the reef event difficult. Close detail is often prevented by the presence of cultivated fields and the inability to obtain permits. The "reef" event often changes character due to changes in the velocity interface between the reef and the overlying shale. This is most likely due to porosity changes in the reef surface.

Figure 6, which shows a portion of two recordings made in the south part of the field, illustrates still another problem. Strong events are recorded locally from within the black shale section. The presence of such transient events beyond a "break" in the reef reflection often makes its identification more difficult. A clue to the identification of the "reef" event in such areas is present in both recordings, however. This is the difference in "stepout" time across the record between the reflection labeled "reef" and those events above it. The importance of such differences cannot be over-estimated in areas where identification is in doubt due to lack of well control.

North-South Recordings

A portion of the recordings taken along a north-south line is shown in Figure 7. Here the shallow events show practically no relief while the reef thins some 200 feet. Of interest is the fact that a deeper event also is essentially flat. In this area, positive identification of the reef is possible.

In obtaining an east-west seismic "time" cross-section, the shooting was done shortly after completion of the discovery well for the south part of the field. As a result of the work done at this time, it was possible to predict that the highest part of the reef would be found east of the discovery well. Few good reef events were recorded for some distance east of the highest part of the field. The presence of an escarpment at this point has been proven by subsequent drilling.

Due to the fact that development of the field is still in progress and many questions are still unanswered concerning it, no seismic contour map can be presented at this time.

Mapping of the Canyon reef in the North Snyder Area by means of reflection shooting is only possible in local areas. The problem is one that demands all the resources of both the geologists and geophysicists concerned with the area. One might go even further and say that the use of the reflection method in detailing a reef is one of the most difficult problems in geophysics today.

One of the first lessons to be learned by interpreters new to such an area is the fact that no reef reflection is continuous for any great distance. Local discontinuities are caused by surface and subsurface conditions. For this reason, if larger features of the area are to be determined, very close detail is imperative since each zone of poor reflection must be circumvented if possible. Often this is impossible due to cultivated areas or lack of permits.

All of the factors previously enumerated must be weighed against the possible returns to be expected by any operator considering this type of exploration. The problem of locating other reefs similar to North Snyder should be a challenge to the entire geophysical profession.

ACKNOWLEDGMENT

The author wishes to thank Deep Rock Oil Corporation and the Sunray Oil Corporation for permission to reproduce the records and cross-section used in this article.

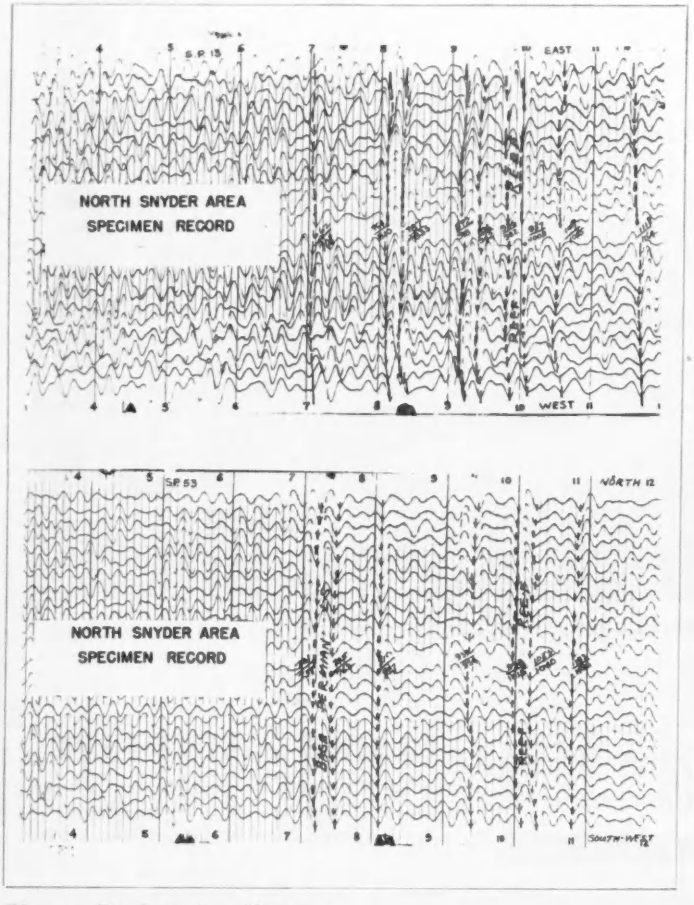


FIGURE 6
(Left)

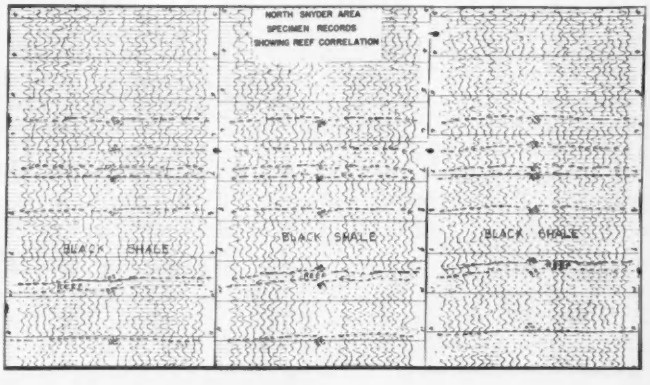
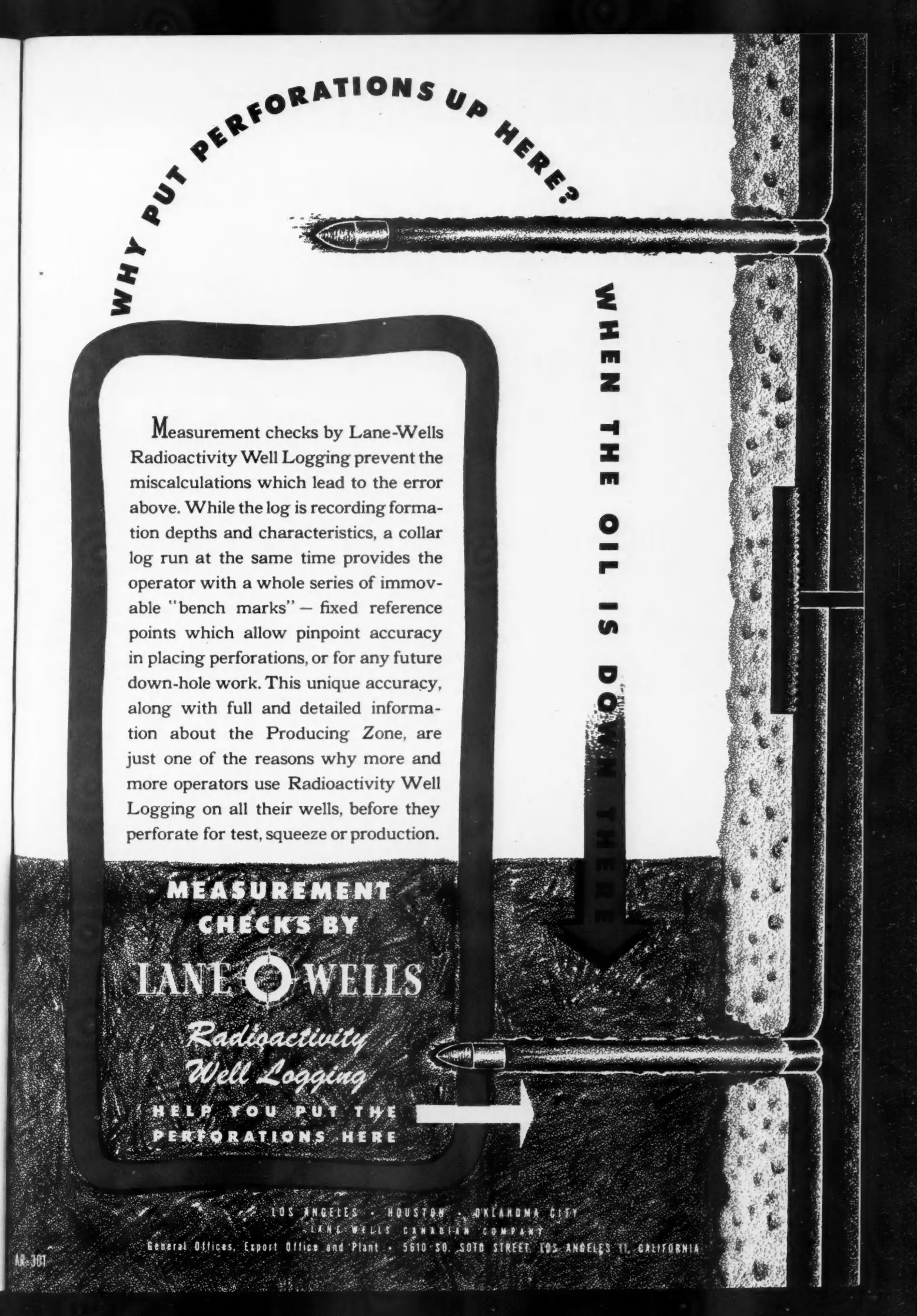


FIGURE 7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Exploration

Sets Record in 1949

A RECORD high in exploratory drilling was reached in 1949 when 7452 such wells were completed to top by 3.5 percent the previous high mark of 7197 wells drilled in 1948. Not only were exploratory wells more numerous, but they also improved on the previous year's producer-to-dry hole ratio to make 1949 a comparatively successful year.

Exploratory drilling in 1949 gave the nation 958 new sources of crude, while in 1948 the total was 917. Those new oil pools were composed of 674 new oil fields and 284 new horizons in previously discovered fields. In 1948, oil discoveries had been 610 new oil fields and 307 new pays. Altogether, there were 4.5 percent more oil discoveries in 1949 than in 1948, although there were only 3.5 percent more wells drilled.

Natural gas and distillate discoveries in 1949 amounted to about the same as in the year before, there having been six more distillate finds and ten less gas discoveries in the year just concluded.

Summary of Results of Exploratory Drilling

ITEM	Dec., 1949	Nov., 1949	Twelve Months: January-December 1949	1948	Percent Diff.
Oil Discoveries	72	71	958	917	+ 4.5
New Fields	57	53	674	610	+ 10.5
New Pays	15	18	284	307	— 7.5
Distillate Discoveries	5	7	121	115	+ 5.2
New Fields	3	5	69	70	— 1.4
New Pays	2	2	52	45	+ 15.6
Gas Discoveries	14	12	150	160	— 6.3
New Fields	11	8	122	112	+ 8.9
New Pays	3	4	28	48	— 41.7
Total Discoveries	91	90	1229	1192	+ 3.1
Extensions to Fields	30	32	292	229	+ 27.5
Oil Fields	27	30	261	170	+ 53.5
Distillate Fields	1	1	16	41	— 61.0
Cas Fields	2	1	15	18	— 16.7
Total Prod. Tests	121	122	1521	1421	+ 7.0
Dry Holes	497	545	5931	5776	+ 2.7
Wildcats	476	521	5803	5618	+ 3.3
New Pays	3	4	17	23	— 26.1
Outposts	18	20	111	135	— 17.8
Total Expl'tory Tests	618	667	7452	7197	+ 3.5
Percent Productive	19.6	18.3	20.4	19.7	
Percent Dry	80.4	81.7	79.6	80.3	

(See Table on Pages 76-78)

Results of Exploratory Drilling in December and for 1949-1948, By Districts

State or District	MONTH OF DECEMBER, 1949													TOTAL YEAR, 1949																	
	Productive Tests									Total Productive	Unproductive Tests			Total Exploratory Tests	Productive Tests								Total Productive		Unproductive Tests				Total Exploratory Tests	
	New Fields			New Pays			Extensions				Wildcats	New Pays	Outposts		New Fields			New Pays			Extensions			12 Mo. 1949	12 Mo. 1948	Wildcats	New Pays	Outposts	Total Dry 12 Mo. 1949	Total Dry 12 Mo. 1948	12 Mo. 1949	12 Mo. 1948
	Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas						Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas									
Alabama											2			2												13			13	19	13	19
Arizona																										5			5	4	5	4
Arkansas											13			13	6		2	5			1			14	8	80	1	4	85	105	99	113
California							1			1	22	1	2	26	10		3	10			15		2	40	59	350	8	14	372	198	412	257
Colorado			1							1	6			7	1		1							2	8	47		1	48	50	50	58
Florida											1			1												15			15	24	15	24
Georgia																										4			4	3	4	3
Illinois	1			1			3		2	7	89			96	23			32			54		4	113	96	653			653	555	766	651
Indiana	1		2							3	10			13	37		5	3			5			50	45	363			363	290	413	335
Iowa																															
Kansas	4									4	37			41	75		5	4			6			90	81	411			411	480	501	561
Kentucky	2			1			1			4	6			10	16			2			3			21	42	58			58	182	79	224
Louisiana	3	1		1	1	1	2			9	15	1		25	31	17	5	28	16	2	13	2		114	118	221	1	1	223	243	337	361
North Louisiana	3				1		2			6	9	1		16	11	4	2	5	9		6			37	24	124	1		125	132	162	156
South Louisiana		1		1		1				3	6			9	20	13	3	23	7	2	7	2		77	94	97		1	98	111	175	205
Maryland																	1							1						1	1	1
Michigan	1			1						2	18			20	19		2	1		1	5			28	23	300		1	301	253	329	276
Mississippi	1						1			2	10			12	6	1		2			1			10	7	114		3	117	115	127	122
Missouri											4			4												17			17	23	17	23
Montana	1									1	2			3	5	1	1	1			1			9	6	36		1	37	33	46	39
Nebraska											1			1	1									1		8			8	6	9	6
Nevada																														1		1
New Jersey																														1		1
New Mexico	1		1				1			3	5	1		9	14		3	5			4			26	19	59	1	3	63	90	89	109
New York																														33		33
North Dakota											1			1												5			5	2	5	2
Ohio											1			1							3		1	4	14	32			32	37	36	51
Oklahoma	6		1	1	1		1			10	41			51	63	3	9	25	3	5	25	1		134	117	451			451	446	585	563
Pennsylvania																	2							2	21	2			2	69	4	90
South Dakota																										6			6	3	6	3
Tennessee															1									1	6	20			20	46	21	52
Texas	33	2	6	10		2	17	1		71	179		16	266	347	47	71	156	33	20	115	13	8	810	684	2376	6	75	2457	2330	3267	3014
Dist. 1 S. Central		1								1	22			23	15	1		2			3		1	22	12	234		5	239	192	261	204
Dist. 2 Middle Gulf	1	1	2	1			1			6	10		1	17	10	17	14	10	8	4	3	6	3	75	79	151		7	158	186	233	265
Dist. 3 Upper Gulf	1			2						3	22		3	28	18	15	7	48	11	3	6	3	1	112	125	238	1	8	247	272	359	397
Dist. 4 L. Gulf-SW.	5		1	3		2	1			12	22			34	24	11	16	37	12	10	7	1	1	119	111	316	1	8	325	357	444	468
Dist. 5 E. Central			1							1	8			9	2	1	1			1		1		6	7	74		1	75	88	81	95
Dist. 6 Northeast	1						1	1		3	9		2	14	12	2	2	1	2		1	2	1	23	20	74	2	4	80	70	103	90
Dist. 7-B N. Central	7		2							9	27		2	38	112		18	17		1	8			156	132	532	2	9	543	422	699	554
Dist. 7-CW. Central	4			1			1			6	15			21	21		4	11			12			48	26	109		3	112	90	160	116
Dist. 8 West	7			2			11			20	8		3	31	41		2	14		1	54		1	113	87	174		13	187	191	300	278
Dist. 9 North	7			1			2			10	35		5	50	91		7	16			21			135	83	467		17	484	456	619	539
Dist. 10 Panhandle											1			1	1									1	2	7			7	6	8	8
Utah											2			2	2						1			3	5	22		1	23	12	26	17
Virginia																									1	1			1	2	1	3
Washington											1			1												1			1	11	1	11
West Virginia																	11							11	21	5			5	25	16	46
Wyoming	3									3	10			13	17		1	10			9			37	40	128		7	135	84	172	124
Total U. S.	57	3	11	15	2	3	27	1	2	121	476	3	18	618	674	69	122	284	52	28	261	16	15	1521	1421	5803	17	111	5931	5776	7452	7197

CUTTING COSTS ACROSS THE COMITE...

Another Republic Electric Weld Pipe Line 50 miles long

Right: 12" Republic Electric Weld Line Pipe with river clamps installed.

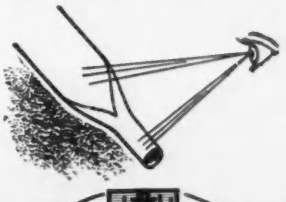
Below: Comite River crossing in Louisiana.

● Builders of this 12" pipe line, constructed in 1946 between Liberty, Mississippi, and Baton Rouge, Louisiana, lost little time in crossing Louisiana's Comite River. Here again, Republic Electric Weld Line Pipe proved that its ease of bending and welding, its uniform wall thickness and roundness, its uniform straightness and long lengths sharply cut installation time and costs.

Yes, these six of its ten outstanding qualities can help solve your installation problems . . . and the combination of all ten, listed at right, means trouble-free line performance throughout a dependable long life.

During the past twenty-one years, more than 55,000 miles of Republic Electric Weld Line Pipe has been placed in service carrying crudes, gasoline, natural gas and by-products.

1. **Uniform Roundness**—Pipe ends match perfectly . . . speed construction . . . cut costs.
2. **Uniform Diameter**—No "off-size" lengths to cause welding difficulties at joints.
3. **Uniform Wall Thickness**—Absolute dependability throughout every inch of length and circumference.
4. **Uniform High Yield Strength**—Permits building higher pressure lines—utilizing design values to fullest advantage.
5. **Uniformly Straight**—Lengths line up evenly . . . go into the ditch freely.
6. **Easy to Bend**—High ductility steel makes bending in the field easy.
7. **Easy to Weld**—Low carbon steel welds readily . . . makes sound joints.
8. **Freedom From Scale**—Insures against clogged valves, contamination of petroleum products.
9. **Long Lengths**—Reduces number of joints . . . makes jobs move with longer strides.
10. **Inspected Inside and Out**—Republic Electric Weld Line Pipe is made from flat-rolled steel both sides of which are closely inspected. Thus, you are assured that the surface which becomes the inside wall when formed into pipe is free from hidden defects.



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New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in December, 1949

Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		CALIFORNIA—Oil Field Extension						
Santa Barbara	Cuyama, S.	Richfield Oil Corp's Heller 36-26, 1669 n 3597 w fr SEC Sect. 26-10n-26w, ½ mi nw extension.	12-20-49	4568	4512- 4542	Dibblee sd; Mio	P 4; 4 wtr; ¾"	....
		COLORADO—New Gas Field						
Mesa	Asbury Creek	Amerada Pet. Corp's Unit 1, C SE NE 14-9s-101w	12-15-49	4223	2833- 2873	Dakota sd; U. Cre	2 mln	....
		ILLINOIS— New Oil Field						
Montgomery	Panama	McGaw & Hughes Pet. Co's Grabruch 1, SE NW SW 23-7n-4w, 1 mi n Panama Gas fld.	12-20-49	807	790- 796	Bethel sd; Miss	P 6	....
		ILLINOIS—New Oil Pay						
Wabash	Lancaster, S.	Ashland O&R Co. et al's M. C. Koertage 1, NW SE NW 21-1n-13w	12-13-49	2529	2518- 2524	Bethel sd; Miss	P 94	....
		ILLINOIS—Oil Field Extensions						
Effingham	Louden	E. C. Reeves et al's Taylor 1, NE SW SW 19-8n-4e, ½ mi se extension	12-31-49	1573	1563- 1570	Cypress sd; Miss	P 70	....
Fayette	Louden	W. L. Belden's M. Griffin 1, NW NE NE 25-8n-3e, ½ mi e extension	12- 6-49	1587	1567- 1585	Cypress sd; Miss	P 14; 15 wtr	....
Gallatin	Omaha	C. H. Murdick et al's Dixon 1, NW SW SW 27-7s-8e, ¾ mi n extension	12-31-49	1510	1495- 1507	Biehl sd; Penn	P 80	....
		ILLINOIS—Gas Field Extensions						
Bond	Panama Gas	T. R. Kerwin's Howard 1, NE NE NW 30-7n-3w, 2 mi ne extension	12-13-49	889	870- 872	Bethel sd; Penn	0.2 mln	....
Morgan	Waverly Gas	Murwood O&G Co's Doolin-Carr Comm. 1, NE NE NE 16-31n-8w, 1 mi nw extension.	12-31-49	1103	1042- 1060	Devonian	2 mln	....
		INDIANA—New Oil Field						
Posey		Ryan Oil Co's Egli 1, NE SE NE 18-6s-12w, 6 mi ne Mt. Vernon	12- 6-49	2385	2373- 2385	Cypress sd; Miss	P 150	....
		INDIANA—New Gas Fields						
Martin		Carl Miles' Crane 1, NE SW SW 4-3n-4w, 3½ mi ne Loogootee	12-13-49	1525	1495- 1525	Chattanooga sh; Devo	1.8 mln	....
Shelby		Delbert H. & A. Norris' Fee 1, NE NW NE, 16-12n-8e, Liberty Twp	11- 3-49	889	863- 889	Trenton li; Ord	0.2 mln	....
		KANSAS—New Oil Fields						
Ellis		Peel & Hardman's Haas 1, C NL NE NE 2-15s-19w, 1½ mi se Antonino pl.	12-16-49	3703	3697- 3703	Arbuckle li; Ord	P 182; 182 wtr	....
Ellis		The Texas Co's Karlin 1, SW SW SE 9-13s-17w, 1 mi sw Catherine pl.	12- 6-49	3603	3585- 3602	Arbuckle li; Ord	P 144	....
Morris	Burdick	S. P. Loomis & Medmin's Atchinson 1, SW SW NE 15-17s-5e	12- 2-49	2277	2220- 2232	Mississippi sd; Miss	P 40	34
Russell	Claussen, W.	Crown Drlg. Co's Foster 1, SE SE NE 29-12s-14w, 1 mi nw Claussen pl.	12-20-49	2854	2841- 2853	Lansing-K.C. li; Penn	P 12; 5 wtr	39
		KENTUCKY—New Oil Fields						
Daviess		R. Hal Compton's Otto Sampley 1, SW NW NE 17-P-28	12-28-49	1514	1498- 1514	Jackson sd; Miss	P 20	....
Daviess		W. K. Snyder & W. Sargant's Geo. Schwartz 1, C N½ N½ 12-P-27	12-28-49	1855	1848- 1852	McClosky li; Miss	P 125	....
		KENTUCKY—New Oil Pay						
Ohio		S. W. Bardill's Chester Tichnor 1, NE NE NE 7-L-31, 3 mi se Jiolly pl.	12-19-49	1593	1484- 1510	Salem li; Miss	P 7	....
		KENTUCKY—Oil Field Extension						
Webster	Poole Cons.	Iley B. Browning's Osborn Hrs. 1, NE SW SE 13-N-23, ¾ mi s extension	12- 3-49	2020	2004- 2020	Hardinsburg li; Miss	P 105	....
		NORTH LOUISIANA—New Oil Fields						
Caddo	S. Cross Lake	Plymouth Oil Co's Thigpen-Herold 1, NE NE SE 12-17n-16w	12-20-49	6505	4779- 4803	Rodessa li; L. Cre.	F 30; $\frac{2}{64}$"	43
Concordia	Vidalia	R. A. Campbell, Dan L. Reynolds, & Pan-Am Southern Corp's Harris-Interstate 1, 750 fr el 660 fr nl 18-7n-10e, 3½ mi w Vidalia.	12- 5-49	6732	5665- 5668	Wilcox sd; Eoc.	F 136; ⅛"	42
Union	Randolph	Zachry Brooks Drlg. Co's Dora Nelson 1, 1980 fr nl 1989 fr el 29-23n-3w, 3½ mi s 1½ mi w Randolph.	12-30-49	9806	9320- 9327	Smackover li; Jur	F 114; ¾"	42.5
		NORTH LOUISIANA—Oil Field Extensions						
Claiborne	Haynesville, E	Hunt Oil Co's S. W. Owens 2, 561 fr sl 677 fr el 12-23-7w, 2¾ mi ne extn.	12- 1-49	10297	9735- 9944	Smackover "A" li; Jur.	F 446; ¼"	43.7
Lincoln	Hico-Knowles	Feazel Interests & Southwest Gas Prod. Co's L. C. Fretwell 1, C N½ SE SE 17-20n-4w, 2 mi w extension.	11-15-49	9115	8512- 8522 8682- 8708	"D" sd; Jur. Vaughn sd; Jur.	F 123; ¼" F 17; ¼"	57 62
		NORTH LOUISIANA—New Distillate Pay						
Caddo	Rodessa	Arkla Oil Co's M. L. Pitts 5, 2640 fr nl 150 fr el 11-23n-16w	11-14-49	11375	10815-10850	Smackover li; Jur.	F 129; 5.3 mln; open	65
		SOUTH LOUISIANA—New Oil Pay						
Pointe	Lottie	The Texas Co's Lottie Ld & Dev. Co. 2, 1997 n 704 e fr SWC of NE¼	12-15-49	10260	9130- 9132		F 271; $\frac{8}{16}$"	41.8
		SOUTH LOUISIANA—New Distillate Field						
Iberia		Humble O&R Co's St. Lse 1706-W Cote Blanche Bay 1, Lake Sand area	12-30-49	13050	10005-10010		F 36; 5 mln; ¼"	....
		SOUTH LOUISIANA—New Gas Pay						
Assumption	Napoleonville	Floyd L. Karsten's Gus J. Labarrow 1, NW NE 47-12s-13e	12-10-49	6202	6040- 6060		No gge	....
		MICHIGAN—New Oil Field						
Newaygo		Admiral Oil Corp's Dastick et al 1, SE NE NE 9-14n-4w, Denver Twp	12- 1-49	2142	1512- 1533	Berea sd; Miss	P 3	....
		MICHIGAN—New Oil Pay						
Oceana	Stony Lake	Turner Pet. Corp's Rabe 1, SW SE NE 19-13n-18w, Claybanks Twp	12- 9-49	942	931- 940	Berea sd; Miss	P 7	....
		MISSISSIPPI—New Oil Field						
Wilkinson	Possum Corner	Danciger O&R Co's Geo. W. Armstrong 2, 990 nw of SWC Sect. 4, in Sect. 5-4n-2w, 2½ mi se Ellisle fld.	12- 4-49	8307	5083- 5089	Wilcox sd; Eoc	F 35; $\frac{5}{12}$"	30
		MISSISSIPPI—Oil Field Extension						
Wayne	Yellow Crk	Magnolia Pet. Co's Oscar Barnett 1, C SE SE SE 3-9n-8w, ¾ mi nw extn.	12-20-49	5220	5118- 5139	City Bank sd; U. Cre.	P 96	18.6
		MONTANA—New Oil Field						
Fallon		Husky Refg. Co's NPRR 1, C NE NE 7-4n-62e, Baker-Glendive area	12- 7-49	6834	6817- 6824	Madison li; Miss	P 12; 37 wtr	....
		NEW MEXICO—New Oil Field						
Lea		Atlantic Refg. Co's Dickenson 1-A, 660 fr n&wl Sect. 13-15s-37e	12- 9-49	11325	11272-11325	Mississippi li; Miss	F 305; ⅜"	41.1
		NEW MEXICO—Oil Field Extension						
Eddy	Loco Hills	Kersey & Co's Dunn 1, 1980 fr n&wl Sect. 12-18s-28e, 1½ mi w extension	12-15-49	2650	2353- 2650	Grayburg li; Perm	F 360	36
		NEW MEXICO—New Gas Field						
Chaves		DeKalk Agric. Assn's Cole 1, (OWWO), 1980 fr s&el Sect. 18-11s-27e	12- 1-49	6630	6269- 6281	Devonian li; Devo	0.5 mln; open	....
		OKLAHOMA—New Oil Fields						
Carter		T. H. McCasland et al's McClure 1, SE SW SE 15-5s-1e, 2 mi e Brock pl.	12- 8-49	6340	3846- 3870	Tulip Creek sd; Ord	F 48; 3 mln;1"	41.5
Grant		Anderson-Prichard Oil Corp's Elva Hamburg 1, NE NE SE 21-26n-3w, ne of Lamont.	12-27-49	5427	4850- 4905	Mississippi li; Miss	P 12; 35 wtr	....
Kay		Dave Morgan Oil Co's G. E. Coles 1, C N½ NE SW 20-27n-4e	12-22-49	3238	3194- 3235	Bartlesville sd; Penn	F 10; ½"	....
McClain		Sinclair O&G Co's D. S. Williams 1, (OWDD), C NW SW 18-5n-2w	12-30-49	9458	8368- 8387	Bromide sd; Ord	SW 55	29.4
Okfuskee		Mid-Continent Pet. Corp's Berta Fleming 1, SE SW NE 9-11n-11e	12-12-49	3708	3694- 3708	Wilcox sd; Ord	P 50	39
Pottawatomie		Gulf Coast Western Oil Co. et al's Rose 1, NE SW SW 10-10n-4e, 2 mi se Shawnee pl.	12-22-49	5527	5496- 5527	Wilcox sd; Ord	P 48; 175 wtr	34.6
		OKLAHOMA—New Oil Pay						
Creek	Olive Dist.	Mitchell & Anderson-Brown's Beavers 1, (OWWO), SW SW NE 12-17n-8e	12-15-49	3042	2936- 2945	Dutcher sd; Penn	P 100	....
		OKLAHOMA—Oil Field Extension						
Major	Ringwood	Mazda Oil Corp's Black 1, NE NW NW 12-21n-10w, 1½ mi se extension	12- 8-49	6950	6804- 6886	Manning sd; Penn	F 40; ¾"	....
		OKLAHOMA—New Distillate Pay						
Cleveland	Moore, SE.	Faultline Oil Corp's School Land 1, (OWWO), C NE NW 36-10n-2w	12-16-49	7406	6440- 6550	Bartlesville sd; Penn	F 36; 1.5 mln; $\frac{11}{64}$"	....
		OKLAHOMA—New Gas Field						
Okfuskee		T. A. Manhart's Palmer 1, SE SE SW 27-10n-9e, 1 mi nw Papoose fld.	12-15-49	3343	3324- 3343	Cromwell sd; Penn	7.5 mln	....
		TEXAS—District 1 (S. CENTRAL)—New Distillate Field						
McMullen		Delhi Oil Corp's Hagist Ranch, Inc. 3, (OWWO), 467 fr nl 2447 fr el G. B. Kinney Sur 481, 1¼ mi sw Loma Alta-Wx fld.	12- 9-49	6920	6847- 6861	Wilcox sd; Eoc	F 14; 11 mln;	....
		TEXAS—District 2 (MIDDLE GULF)—New Oil Field						
Bee	Blanconia, E.	W. R. Quin et al's Bessie Barber et al 1, 330 fr nw&sl of 96.8-ac Lse, Jas. & Wm. St. John Sur, 1½ mi se Blanconia fld.	12-21-49	5255	5249- 5255	Sultex sd; Olig.	F 80; $\frac{11}{64}$"	30
		TEXAS—District 2 (MIDDLE GULF)—New Oil Pay						
Victoria	Placedo, E.	P. R. Rutherford, Heep Oil Corp. & Conroe Drlg. Co's Mrs. Ben Shelton 1-B, 330 fr nwl 3250 fr swl Placedo Benavides Sur, ¾ mi s of prod.	12-14-49	7796	7428- 7431		F 161; ⅛"	44.2
		TEXAS—District 2 (MIDDLE GULF)—Oil Field Extension						
Lavaca	Vienna	Oil Drilling Inc's Alton C. Allen et al 2, 3200 fr nel 3800 fr nw M. Muldoon Sur, 1¾ mi ne extension.	11-21-49	8501	8492- 8501	Wilcox sd; Eoc	F 86; 14 wtr; ⅛"	38
		TEXAS—District 2 (MIDDLE GULF)—New Distillate Field						
Live Oak		Western Natural Gas Co's Blk 77 Unit 1, 467 fr n&wl Blk 77, Simmons Sbdn R. W. Fant Sur 18, ½ mi sw Clayton fld.	12- 5-49	7063	6852- 6860	Wilcox sd; Eoc	F 72; 2.2 mln; ¼"	57.9
		TEXAS—District 2 (MIDDLE GULF)—New Gas Fields						
Calhoun		John W. Mecom's Minnie S. Welder 3, on sel of SA&MGRR Sur 3	12- 1-49	9105	5740- 5755		No gge	....
Live Oak		Henderson Coquat's W. H. Herring 1, 5800 fr sl 1300 fr el J. Buchanan Sur.	12-27-49	6934	6910- 6918		113 mln. open	....

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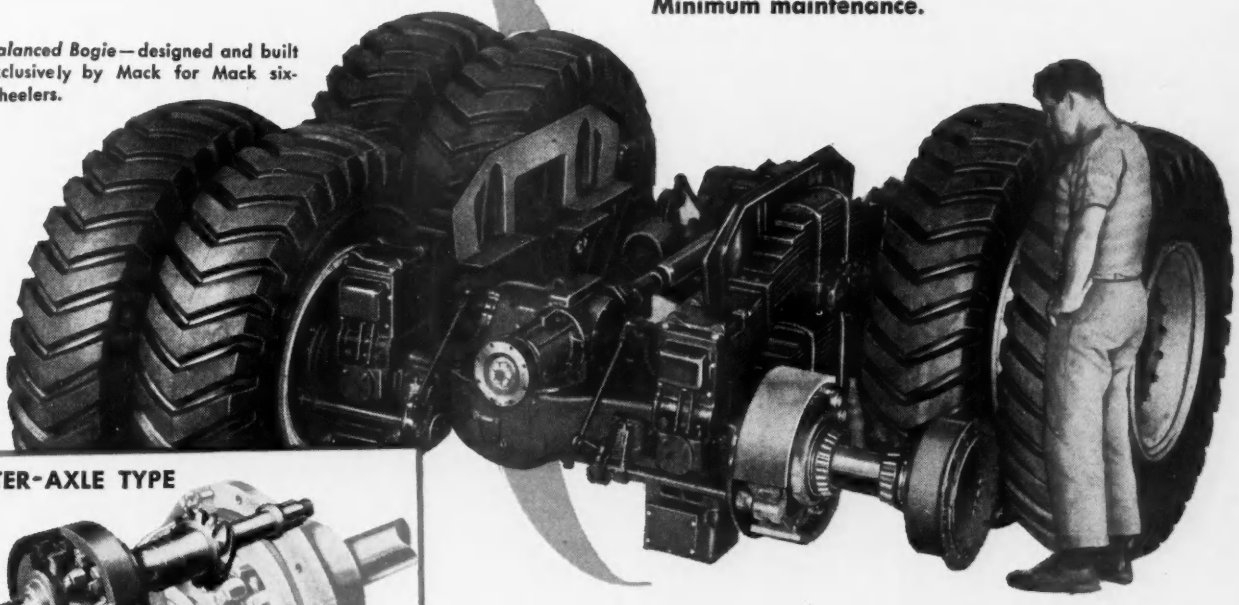

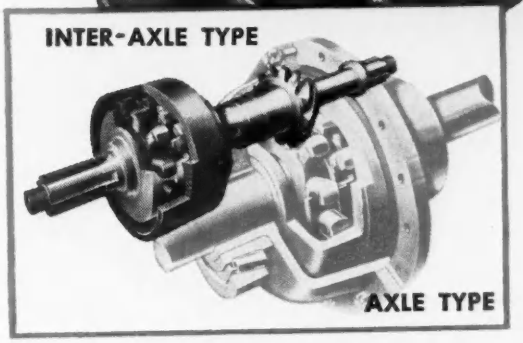

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New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the U. S.—Continued

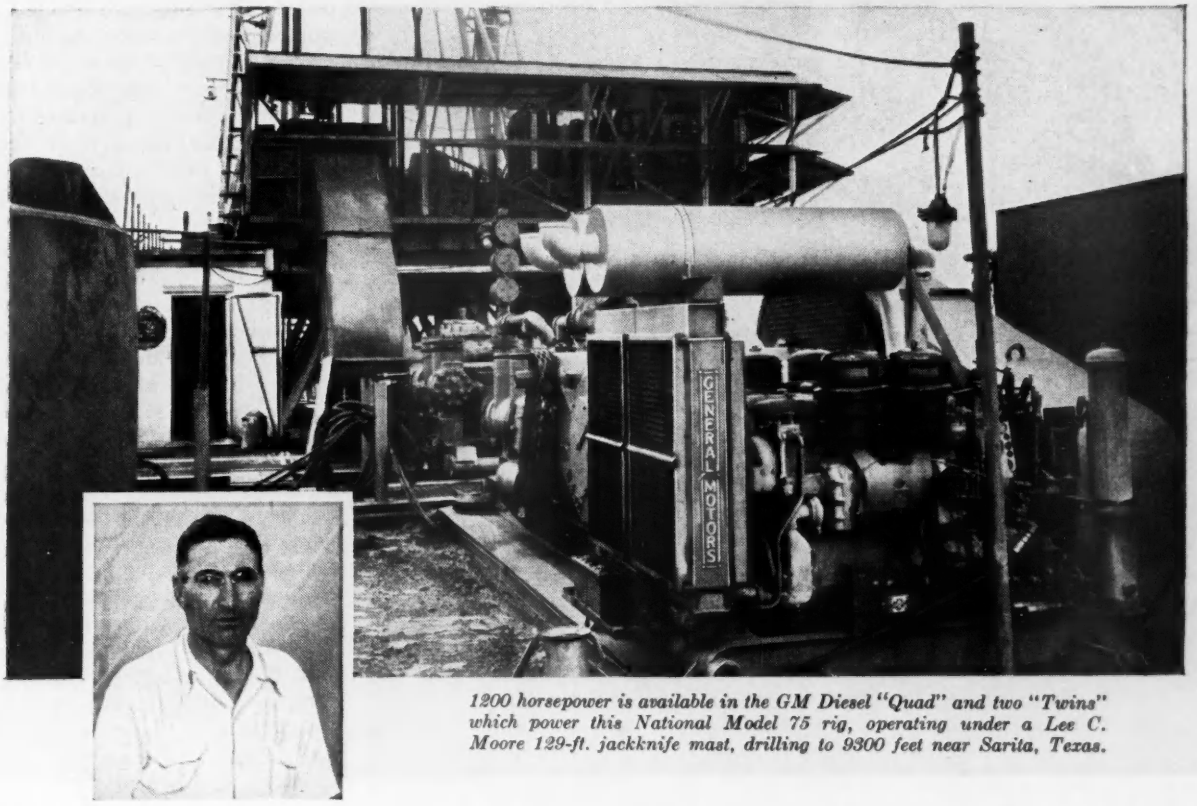
COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		TEXAS—District 3 (UPPER GULF)—New Oil Field						
Tyler		P. T. Sharples' D. D. Swearingen 1, 660 fr n&el W. R. Parker Sur.	12- 5-49	9371	5696- 5697	Cockfield sd; Eoc	F 120; $\frac{1}{2}$"	46
		TEXAS—District 3 (UPPER GULF)—New Oil Pays						
Liberty	Hull	General Crude Oil Co's Phoenix Dev. Co. 5, 5600 fr s&el J. Devore Lge.	12-16-49	6600	5560- 5564		P 90	39.5
Liberty	S. Liberty	L. M. Josey et al's Joseph Mitchell 2, (OWWO), 400-ac Tr.	12-16-49	7532	5743- 5775	EY No. 1 sd; Eoc	F 246; $\frac{3}{16}$"	38.3
		TEXAS—District 4 (LOWER GULF-SW.)—New Oil Fields						
Duval		Ammann-McNab, Ltd, et al's A. Weil Est. 1, 2310 fr sel 330 fr swl B. Elizondo Sur 568, in East Peters area.	12-22-49	3860	3790- 3791		F 31; 160; $\frac{1}{4}$"	32.5
Duval		E. B. Cox & J. L. Hamon's J. Benavides 1, 330 fr nl 4052 fr el BS&F 462	12- 8-49	3700	3575- 3577		P 50	38.6
Duval		Orlee Oil Co's L. Lopez 1, 1750 fr el 1950 fr sl of 342.07-ac Lse, J. Poitevent Sur 455, 21 mi n Bruni.	12-27-49	1713	1699- 1702		P 25	20
Duval	Forty Nine	The Texas Co's Duval Co. Ranch O/A NCT-2 1, 330 fr sw&esl of NW¼ GB&CNGRR Sur 49, 1 mi n Colmena fld.	12-18-49	2622	1574- 1586	Cole sd; Eoc.	P 20; 14 wtr	21.3
Jim Wells	Palo Hueco	The Texas Co's E. M. Brownlee 1, 1650 fr se&swl SPRR Sur 17.	12-11-49	5700	3353- 3358	Frio sd; Olig.	P 61; 30 wtr	24.3
		TEXAS—District 4 (LOWER GULF-SW.)—New Oil Pays						
Aransas	Mud Flats	Geo. W. Graham, Ryan, Hays & Burke's D. W. Grant 1, (OWWO), 818 fr nel 2092 fr nwl D. C. Barnett Sur.	12-28-49	9525	8559- 8562		F 185; $\frac{5}{64}$"	41
Jim Hogg	Edlasater	Gorman & DeLange et al's Mary M. Lasater Est. 3, 990 fr mst w'ly el 1320 fr mst s'ly sl Sh 1, Part. 5518, Sam Honey Sur 270.	12-16-49	2215	2096- 2098	Mirando sd; Eoc	F 13; $\frac{1}{64}$"	
Starr	Jay Simmons	C. G. McCaleb & W. Earl Rowe et al's Jose G. Garcia 1, 330 fr el 3315 fr sl Sh. 4, Sbdn "C", Santa Cruz Gr.	12- 2-49	6455	6029- 6033		F 91; $\frac{1}{64}$"	41.3
		TEXAS—District 4 (LOWER GULF-SW.)—Oil Field Extension						
Kenedy	Sarita	Humble O&R Co's W. Mueller Jr. 1, center of Lot 1, Blk 13, 1st Add. to Sarita Twst, El Paistle Gr, 1½ mi nw extension.	12-15-49	9601	3605- 3610		F 30; ⅛"	29
		TEXAS—District 4 (LOWER GULF-SW.)—New Gas Field						
Starr	El Ebanito	Baldridge & King, Inc's T. B. Slick Est. 1, 7000 fr wl 6795 fr sl 5200 fr el El Panal Gr, 2½ mi n-ne Flores fld.	11-20-49	7206	7080- 7104	Vicksburg sd; Olig.	10.3 mln; open	
		TEXAS—District 4 (LOWER GULF-SW.)—New Gas Pays						
Jim Wells	Magnolia City, N.	Frank W. Michaux's Virgil A. Bergh, Tr. 2, 467 fr n&wl Blk 7, Jose Pancheco Sur.	12-29-49	5467	3433- 3460		26 mln; open	
Webb	Moga	H. R. Smith's Duval Co. Ranch Co. 1, 2121 fr el 2646 fr sl Sect. 3, Blk 21. Zapata CSL Sur 3.	12-18-49	1960	1689- 1695	Yegua sd; Eoc	1.8 mln; open	
		TEXAS—District 5 (EAST CENTRAL)—New Gas Field						
Navarro		Ted Weiner et al's W. G. Holleman 1, 10,400 fr swl 2050 fr nwl R. D. Newman Sur, ¼ mi fr oil prod.	11-25-49	3287	3220- 3237	Woodbine sd; U. Cre.	12.5 mln; open	
		TEXAS—District 6 (NORTHEAST)—New Oil Field						
Harrison	N. Lansing	Atlantic Refg. Co's M. P. Isom 1, 3250 fr sl 2100 fr el E. A. Merchant Sur.	12-13-49	7994	6734- 6798	Young li; L. Cre.	F 416; open	53.2
		TEXAS—District 6 (NORTHEAST)—Oil Field Extension						
Smith	Red Springs	Humble O&R Co's A. F. Forston et al 1, 1400 fr nflly nl 660 fr w'ly el Wm. Price Sur, ½ m. nw extension.	12- 2-49	10461	9736- 9762	Mass Anhydrite li; L. Cre	F 57; open	
		TEXAS—District 6 (NORTHEAST)—Distillate Field Extension						
Panola	Carthage	Earl Hollandsworth et al's J. T. Green 1, 1054 fr s'ly nl of 190-ac Tr. & 630 fr sl of J. J. Hooper Sur, 1 mi nw extension.	12-14-49	6860	6632- 6646	L. Pettit li; L. Cre.	F 617; 16 mln; open	65.9
		TEXAS—District 7-C (W. CENTRAL)—New Oil Fields						
Irion		C. M. Page's Mrs. Elta Murphey 1, (OWWO), 660 fr n&wl Sect. 1227, GC&SF Sur, 1 mi nw Monument.	9-25-49	8398	1297- 1620	Clear Fork li; Perm	P 66	34.2
Runnels	"N. Miles"	Drilling & Exploration Co's W. R. Gross 1, 1650 fr nl 330 fr el Sect. 93½, S. Herring Sur, 7½ mi n Miles.	11-24-49	4310	3934- 3946	Palo Pinto li; Penn	P 8; 2 wtr	42
Runnels		Sells Pet. Co's W. W. Mitchell 1, 3700 fr wl 8700 fr nl Burnett CSL 271	11-29-49	4428	4382- 4403	Capps li; Penn	P 12; 5 wtr	44.5
Tom Green		Hiawatha O&G Co's W. G. Currie 1, 660 fr n&wl of S½ of Sect. 19, Blk 25, H&TC Sur, 2 mi s Susan Peak fld.	12- 8-49	4881	4835- 4878	Strawn sd; Penn	F 112; ¼"	37
		TEXAS—District 7-C (W. CENTRAL)—New Oil Pay						
Runnels	Aldridge	S. C. Herring Drlg. Co's A. L. Aldridge et al 1, 3900 fr nl 3700 fr el David Moseley Sur, Sect. 521.	8-22-49	3919	3900- 3914	Gardner sd; Penn	F 124; ¼"	42
		TEXAS—District 7-C (W. CENTRAL)—Oil Field Extension						
Runnels	Fort Chadbourne	N. P. Powell & T. W. Murray's Odom Est. 1, 330 fr nw&swl Lot 286, G. Carroll Sur, 1½ mi s extension.	12-14-49	5337	5290- 5333	Strawn sd; Penn	F 1820; ¾"	46
		TEXAS—District 8 (WEST)—New Oil Fields						
Andrews		Stanolind O&G Co's David Fasken 1-H, 660 fr n&el Sect. 37, Blk 42, T-1-N, G&MMB&A Sur, 13¾ mi e Cowden, N. fld.	12-28-49	4909	4750- 4843	Grayburg li; Perm	P 55; 24 wtr	31
Borden		Amerada Pet. Corp's N. C. Von Roeder 1, 1958 fr wl 667 fr sl Sect. 103, Blk 25, H&TC Sur, 4 mi w Sharon Ridge Canyon fld.	12-21-49	7556	7100- 7110	Canyon Reef li; Penn	F 185; 33 wtr; $\frac{3}{8}$"	38.8
Gaines		Mid-Continent Pet. Co's L. R. Nichols 1, 660 fr n&wl Sect. 7, Blk 10-A, PSL Sur, 5 mi e Hobbs pl.	12- 7-49	7510	6390- 6448	Glorietta li; Perm	P 97; 11 wtr	34
Kent	"Cogdell"	J. A. Chapman Prod. Co's D. M. Cogdell 1, 467 fr s&wl Sect. 716, Blk 97, H&TC Sur, 8 mi n&e of N. Snyder fld.	12-17-49	6857	6841- 6847	Canyon Reef li; Penn	F 596; ½"	41.7
Pecos		La Gloria Corp's La Verne L. Cresse 1, 1980 fr wl 660 fr sl Sect. 78, Blk 11, H&GN Sur, 7 mi nw Wentz-Ellen fld.	12-13-49	5100	4753- 4777	Simpson li: Ord	P 105	46.4
Pecos		Neb-Tex Oil Co's F. Malicky 1, 330 fr nw&nel of N¼ of W¼ Sect. 15, Blk 3, H&TC Sur, 1½ mi n of Lehn, N. fld.	12- 7-49	1992	1964- 1992		F 61; $\frac{1}{32}$"	36
Scurry		C. L. Norsworthy, R. W. Baxter, Standard-Fryer & Ted Weiner's D. D. Feldman 1, 660ffr n&wl Sect. 63, Blk 3, H&TC Sur, 11 mi e Snyder.	10-13-49	7362	7309- 7335	Ellenburger dolo: Ord	P 121	42
		TEXAS—District 8 (WEST)—New Oil Pays						
Gaines	Robertson	Samedan Oil Corp's Andrews 1-D-E-A, 660 fr nl 1980 fr el Sect. 19, Blk 24-A, PSL Sur.	12-12-49	12090	10056-10070 11900-11960	Devonian li; Devo. Ellenburger li; Ord	F 255; $\frac{1}{32}$" F 263; 1"	36
Scurry	Kelley	Sun Oil Co's Mae Lemons 2, 853 fr sl 1787 fr el of SW¼ Sect. 205, Blk 97, H&TC Sur.	12- 7-49	7680	7665- 7680	Strawn sd; Penn	F 110; ¼"	39
		TEXAS—District 8 (WEST)—Oil Field Extensions						
Crane	Block 31—Devonian	Atlantic Refg. Co's University 1-HH-31, 660 fr s&wl of N½ of Sect. 23, Blk 31, Univ. Lds Sur, ¾ mi n extension.	12- 7-49	9103	8814- 8988	Devonian li; Devo.	F 205; ⅜"	45.9
Crane	Sand Hills-McKnight	Herman Brown's Hattie Connell et al 1, 330 fr s&el Sect. 8, Blk 26-B, PSL Sur, 1¼ mi n extension.	12- 5-49	3489	3269- 3314	McKnight li; Perm	P 55	33
Dawson	Sprayberry Deep	Seaboard Oil Co's J. H. Robinson S-D-A, 600 fr nl 1748 fr wl Sect. 37, Blk 34, T-5-N, T&P Sur, ne extension.	12-17-49	6780	6498- 6772	Sprayberry sd; Penn	F 319; ¼"	33.6
Mitchell	Dockrey	Superior Oil Co's Jim Plaster 2, 1980 fr s&el Sect. 4, Blk 28, T-1-S, T&P Sur, 2 mi n&e extension.	11-29-49	7992	7987- 7992	Ellenburger li; Ord	F 338; $\frac{1}{32}$"	44.9
Pecos	Lehn	Nash & McKay's Iowa Realty Trust 1-A, 330 fr ne&sel Sect. 73, Blk 10, H&GN Sur, 1 mi ne extension.	12- 9-49	1720	1679- 1720	Seven Rivers sd; Perm	F 82; ½"	33
Scurry	Diamond-M	Velma Pet. Corp's J. L. Green 1, 607 fr s&wl Sect. 213, Blk 97, H&TC Sur, ½ mi n extension.	12-17-49	6792	6681- 6792	Canyon Reef li; Penn	F 496; $\frac{23}{64}$"	43
Scurry	Kelly-Canyon	Standard Fryer Drlg. Co. & Star Oil Co's J. B. York 1, 660 fr n&wl Sect. 180, Blk 3, H&GN Sur, 2¼ mi nw extension.	11-29-49	6764	6720- 6764	Canyon Reef li; Penn	F 552; $\frac{11}{64}$"	43
Scurry	Sharon Ridge Canyon	R. E. Smith's Marsh Springer 1, 660 fr s&el Sect. 123, Blk 25, H&TC Sur, ½ mi n extension.	12-15-49	6712	6705- 6712	Canyon Reef li; Penn	F 535; ¼"	44
Scurry	N. Snyder	Seaboard Oil Co's R. C. Lunsford 1, 467 fr n&wl of SW¼ Sect. 19, Blk 1, J. P. Smith Sur, 1 mi w extension.	12-17-49	6783	6406- 6504	Canyon Reef li; Penn	F 644; ⅜"	44
Scurry	N. Snyder	Sunray Oil Corp's J. W. Newton 1, 507 fr nl 517 fr el SW¼ Sect. 160, Blk 3, H&GN Sur, ½ mi s extension.	12-11-49	6850	6630- 6730	Canyon Reef li; Penn	F 887; ½"	44
Scurry	N. Snyder	The Texas Co's P. L. Fuller 1, 467 fr s&wl Sect. 497, Blk 97, H&TC Sur, ¾ mi ne extension.	12-31-49	6890	6812- 6890	Canyon Reef li; Penn	F 857; 1"	43
		WYOMING—New Oil Fields						
Converse		Steelco Drlg. Co's McDonald 1, C S½ NE SE 32-34n-75w, ¼ mi n Glenrock	12-30-49	7258	7202- 7226	Muddy sd; U. Cre.	F 504; ⅛"	
Hot Springs		Farmers Union Central Exchange, Inc's Gov't-Shad 1, SE SE SE 6-43n-91w.	11-17-49	5210	4390- 4440	Tensleep sd; Penn	F 192	34
Johnson		Delhi Oil Corp's Federal-Hill 1, SE NW NE 35-42n-78w, 1½ mi s Sussex, SE, fld.	12-23-49	4513	3937- 3992	Sussex sd; L. Cre.	F 500; ¾"	40.5

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formation abbreviated thus: Plio, Pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hour rate), flowing, (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke in inches.

"This Rig has Everything"

says Charles D. Bryant
Allen & Morris Drilling Co.



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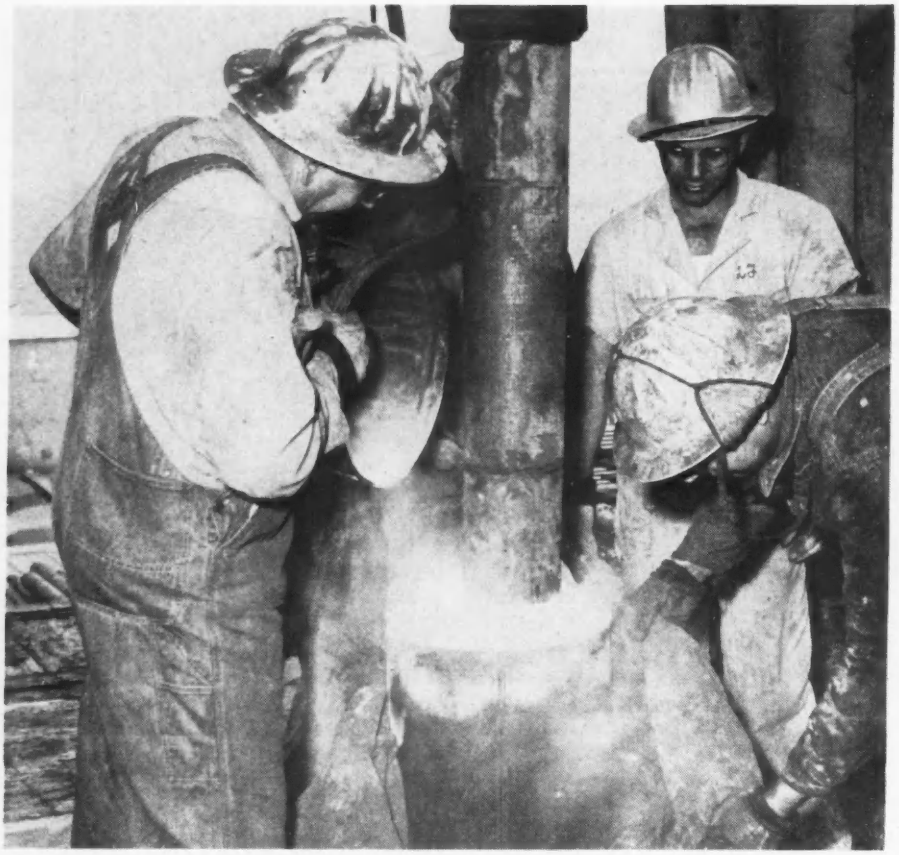
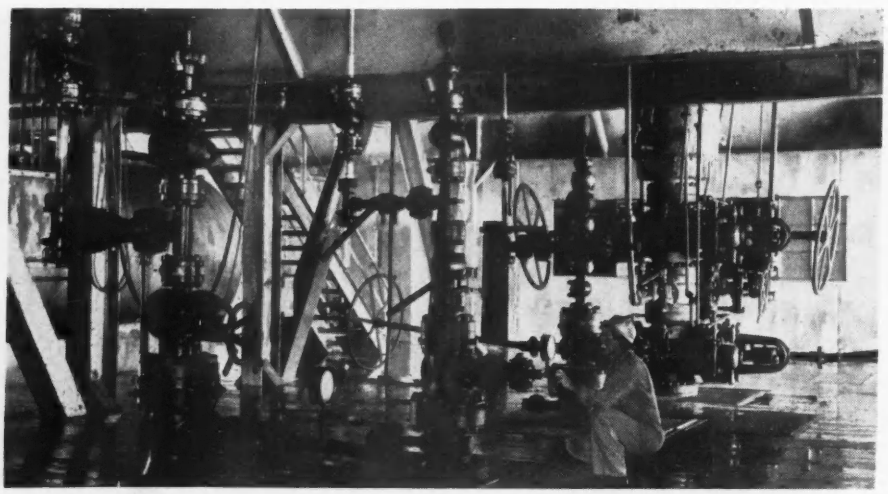
Dry Ice Prevents Blowout



Drilling crewmen pack pulverized dry ice around drill pipe to control an oil well which threatened to blow out on Humble Oil & Refining Company's marine drilling platform seven miles off Grand Isle, Louisiana. The dry ice froze the drilling mud inside the pipe to effect a temporary seal until a positive shutoff could be installed and the well pressure controlled and quieted.



The christmas trees of three producing oil wells stand beside the blowout preventers of a fourth well being drilled on the lower deck. Dry ice freezing was used in working over the well on the left, first completed from the platform. Humble so far has completed seven oil wells and two gas wells in coastal Louisiana waters.

AN UNUSUAL use for dry ice was applied recently by production men of Humble Oil & Refining Company in controlling an oil well seven miles offshore in the Gulf of Mexico. The well, completed in August, 1948, as the first producer on Humble's 1¼ million dollar marine drilling platform off Grand Isle, Louisiana, was being worked over when oil and gas under pressure from below began threatening to blow out, endangering two other oil wells on the platform and the platform itself. The threat was controlled by using dry ice to freeze a solid plug of drilling mud in the drill pipe until a positive shutoff could be installed. The workover job on the well was successfully completed and the three wells on the platform are now producing a combined allowable of about 700 barrels per day.

Mud Forced Out

During workover operations, the pressure of oil and gas in the reservoir 8640 feet down overcame the weight of the drilling mud in the hole, forcing the mud out the top of the well. The three sets of blowout preventers were closed to seal the space between the well casing and the drill pipe, and the 540 feet of drill pipe in the hole was capped by the kelly joint in the normal fashion for drilling. This sealed the well, and the pressure at the surface climbed to 800 pounds per square inch.

The driller's problem was to add more drill pipe to the drill string, to move the bottom of the pipe to the bottom of the well where heavy drilling mud could be pumped in to control the pressure of the oil reservoir. This meant unscrewing the top section of drill pipe under pressure.

Twice fresh water was pumped into the drill pipe and dry ice was packed around the outside of the pipe. Each time oil and gas bubbling up from below kept the water from freezing.

On the third try, viscous bentonite (clay) mud was pumped into the drill pipe and pulverized dry ice was tightly packed in a can around the drill pipe. After two hours during which the ice was constantly tamped tight, the mud was frozen solid, making an effective seal.

The top joint of pipe was then unscrewed and a joint with a positive shutoff plug was installed. The remainder of the drill pipe was made up and lowered through the blowout preventers to the bottom. The plug in the drill pipe was then drilled out and heavy drilling mud was pumped in to control the reservoir pressure and quiet the well.

VIBRATION

Problems in Drill Pipe

By KENNETH N. MILLS
Product Manager, Oil Field Sales
International Derrick & Equipment Company

BASIC CAUSES of drill-pipe vibration are discussed, and mathematical means are presented for evaluating the effect. Basic equations, together with data from a given well, enable the man at the rig to determine critical speeds, and to regulate drilling so as to eliminate danger zones. Typical graphs for standard drill pipe and normal mud are added to permit visual solution of most commonly met problems.

THE problem of drill pipe behavior is of prime importance to the operator of a drilling rig, because it can have a definite effect on drilling costs. If the drill string is not operated under the proper conditions, it will be subjected to adverse loads which will induce additional unnecessary stresses into the pipe. The stresses resulting from these operating conditions will add to those normally existing in the drill pipe and can cause it to fail prematurely. If the drill pipe fails in operation, it must be fished out of the hole and thus create unnecessary expense. The same conditions which induce these stresses can cause the tool joints and drill pipe to wear at an excessive rate, and in addition subject the wall of the open hole to loads which tend to cause wall failures.

As the drill stem is a slender column, the importance of operating it with sufficient drill collars to keep it in tension is generally appreciated. If the drill pipe is not kept in tension that portion of the drill pipe which is in compression will tend to fail as a slender column, causing it to buckle, inducing bending stresses into the drill pipe. The wall of the hole and the magnitude of the compressive load will determine the intensity of the bending stresses induced by the buckling. The general condition of the drill pipe in the hole will be as shown in Figure 1. This condition also causes the drill pipe and the tool joints to scrub the wall of the hole at the point of contact between the pipe and the wall. The abrasive wear on the pipe tends to destroy the wall of the hole. Its action on the wall of the hole is similar to that of a flat object lying on damp ground and subjected to a repeated force normal to the ground. If sufficient moisture is present and the force is continued for a short period of time, the ground surface will deteriorate into a mud puddle. In a like manner, if the wall of a hole in a soft formation is subjected to constant pounding or kneading by the drill pipe it is reasonable to expect it to fail by sloughing.

To assure having the drill pipe in tension, the weight of the drill collars must be adjusted to allow for the buoyant force of the mud on the drill pipe. In a recent API paper by Hawkins and Lamont[1] the following equation was suggested for determining the stress condition in drill pipe:

$$P = \frac{d_1 (L-t)}{144} + \frac{(V_c - V_p)(d_1 - d_2) - W}{a} - \frac{d_2 L}{144}$$

where—

P = Axial stress in drill pipe, pounds per square inch

d_1 = Density of drill pipe and collars in air, pounds per cubic foot

d_2 = Density of mud, pounds per cubic foot

t = Depth at which stress is determined, feet

V_c = Volume of metal in drill collars, cubic feet

V_p = Volume of metal in drill pipe with length equivalent to length of drill collars, cubic feet

a = Cross sectional area of drill pipe, square inches

W = Weight carried on bit, pounds

L = Total length of string, feet

This equation can be used to determine the location of the neutral plane below which the drill pipe is in compression by setting P equal to zero and solving for t. It will be shown later that the neutral plane should be no higher than the top of the drill collars, and to allow for variations in weight on bottom an excess of drill collar weight should be used to assure the maintenance of this condition. The effect of mud buoyancy on drill pipe stress condition is shown in Figure 2, from the above mentioned paper.

As the drill stem is a dynamic member, it is reasonable to expect it to be subject to mechanical vibrations. When the drill stem is analyzed for possible types of vibrations, it is found that it might be subject to two. As it is a long rotating shaft, it can vibrate in the horizontal plane, if it is rotated at a critical speed. All types of rotating shafts are subject to this type of vibration, and these vibrations are self-excited by small dynamic unbalances in the rotating member. As it is a long suspended rod it can vibrate longitudinally or vertically. To vibrate in this manner it must be subjected to a repetitive vertical force which is resonant with its natural frequency of longitudinal vibration. As the cutting action of rock bits and pressure surges from slush pumps produces longitudinal

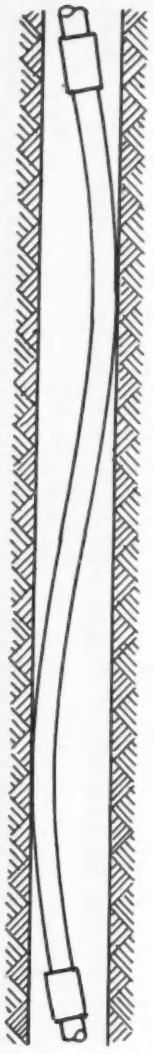


FIGURE 1
(left)

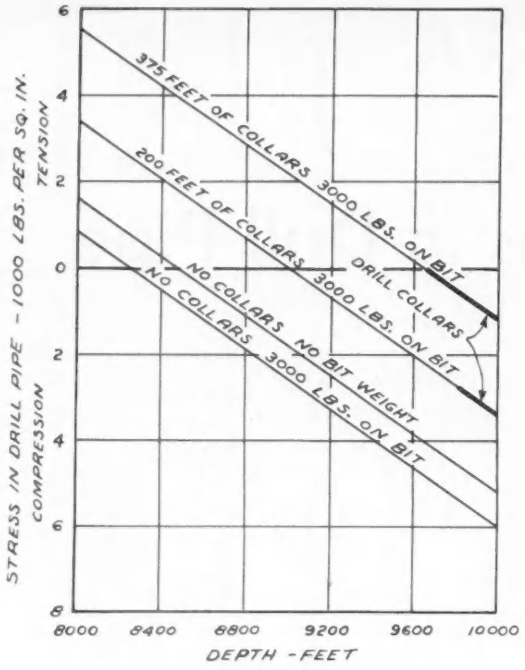


FIGURE 2

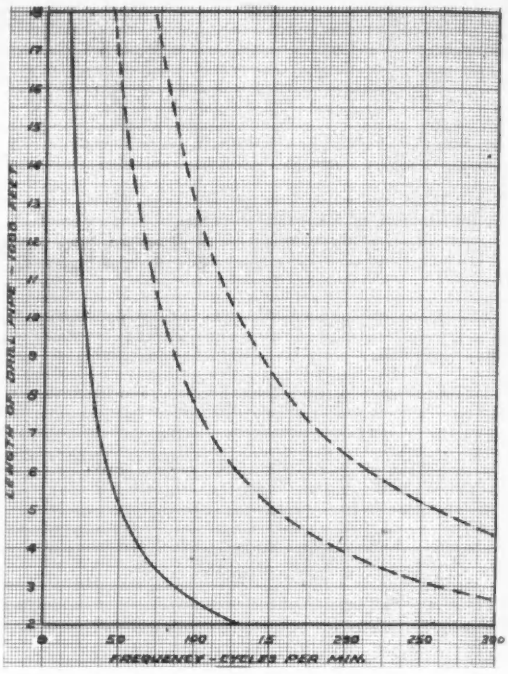


FIGURE 3

forces this possible mode of vibration is worthy of investigation.

The natural frequency of longitudinal vibration of a steel rod fixed at one end and subjected to a suddenly applied force at the free end is represented by the equation

$$f = \frac{258{,}000\ j}{L}$$

where

f = Frequency, cycles per minute
j = 1, 3, 5, 7—
L = Length of rod, feet

In this equation the fundamental frequency is defined when j = 1, and the harmonics are defined when the other values of j are used. From this equation it is apparent that the frequency of longitudinal vibration is independent of the size of the drill pipe and the suspended load on the drill pipe. The natural frequency will be reduced slightly by the damping effect of the mud, but as this effect is small it can be neglected. The variation of the natural frequency of longitudinal vibration and its first two harmonics with depth is shown in Figure 3. The possibility of the drill stem's vibrating in this manner is questionable, because the existence of an exciting force of sufficient intensity to set the drill pipe into vibration is questionable. Two possible sources for this force exist. These sources are the mud pump pulsations and the drill bit. Although the frequency of the pulsations produced by the drill bit is indeterminate, they could have sufficient intensity to excite vibrations and may contribute to drill pipe stresses. Under normal operating conditions it is doubtful that the mud pump pulsations have sufficient intensity to excite vibrations. If the pump is producing severe fluid pounds it could excite vibrations and at moderate depths this force could be resonant with the natural frequency of the drill pipe.

Critical Speed

The most probable mode of vibration in drill pipe is that resulting from operating the drill pipe at a critical speed. This type of vibration will cause the drill pipe to whip violently in a horizontal plane between node points in the drill pipe. As the vibration is in the horizontal plane, it induces bending stresses in the drill pipe and can cause premature failures. Also it will subject the wall of the hole to severe loads which may cause the wall to break down. The critical speed of the drill pipe is influenced by the magnitude and nature of the axial load on the pipe and the density of the drilling mud. Naturally, if the pipe is not rotated at its critical speed, vibrations will not occur. Neglecting the effect of the tool joints, the critical speed of the drill pipe in air and not subject to axial loads is expressed by the equation:

$$C_R = \frac{32{,}600\ n^2}{L^2}\sqrt{D^2 + d^2}$$

where:

C_R = Critical speed, rpm
L = Length of pipe, feet
D = Outside diameter of pipe, inches
d = Inside diameter of pipe, inches
n = 1, 2, 3, ———

If the drill pipe is operating in drilling mud, the mud inside the pipe will increase the inertia of the pipe, and the mud outside will create a frictional force which will tend to damp out the vibrations. The increased inertia of the drill pipe due to the mass of the mud inside the pipe will reduce its critical speed by the ratio:

$$R = \sqrt{\frac{P}{P + O}}$$

where:

R = A multiplier
P = Weight of pipe, pounds per inch of length
O = Weight of mud column inside pipe, pounds per inch of length

The frictional force created by the mud outside the drill pipe will cause a

slight reduction in the critical speed, however, this effect is small and can be neglected. The important effects of damping are to reduce the adverse effects of operating at speeds near the critical.

The predominant factor influencing the critical speed of drill pipe is the axial-force on the drill pipe. Compression will decrease the critical speed. Naturally, if the compressive force is sufficient to cause the pipe to buckle, the critical speed becomes zero, as the pipe is displaced into the position it would assume at the critical speed. The reduction in critical speed caused by compression is represented by the equation:

$$M = \sqrt{L - \frac{SL^2}{EI\pi^2 n^2}}$$

where:

M = Multiple
S = Axial load, pounds
L = Length of pipe inches
I = Moment of inertia of pipe
E = 29 million
n = 1, 2, 3 ———

Axial tension will increase the critical speed of the pipe and this effect can be evaluated with the equation

$$M = \sqrt{L + \frac{SL^2}{EI\pi^2 n^2}}$$

Stiffening Effect

To apply these equations to the drill stem, the local stiffening effect of the tool joints must be considered, because practical rotating speeds correspond to the high order harmonics of the natural frequency. If pipe lengths corresponding to the span between two or more tool joints are considered, the equation for the fundamental (n = 1) can be applied to this reduced length. It will be shown later than lengths of 1, 2, and 3 joints are the only lengths worthy of consideration and the importance of this type vibration decreases as the distance between node points increases. These three modes of vibration are illustrated in figures 4, 5 and 6.

The variation of critical speed with length for several sizes of drill pipe operating in air is shown in Figure 7. In this chart it will be noted that the critical speed increases as the diameter of the pipe is increased, and it decreases as the length between the tool joints assumed to be fixed is increased.

The relationship between axial tension and the critical speeds corresponding to

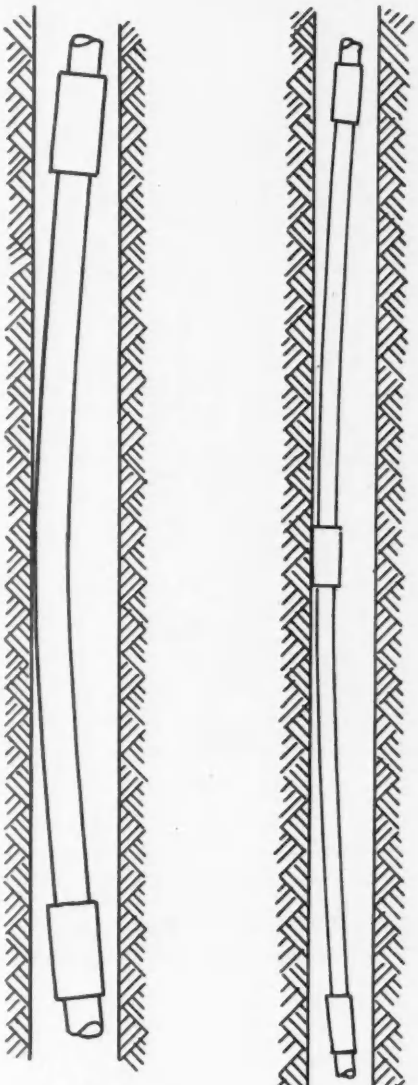


FIGURE 4

FIGURE 5

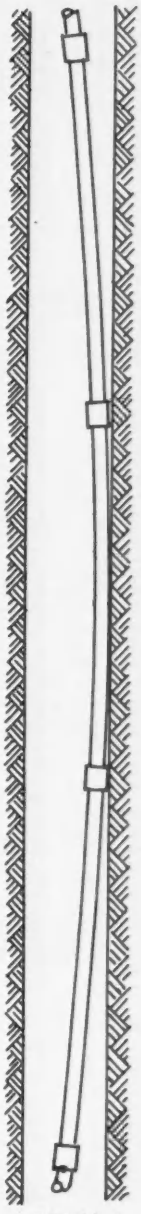


FIGURE 6

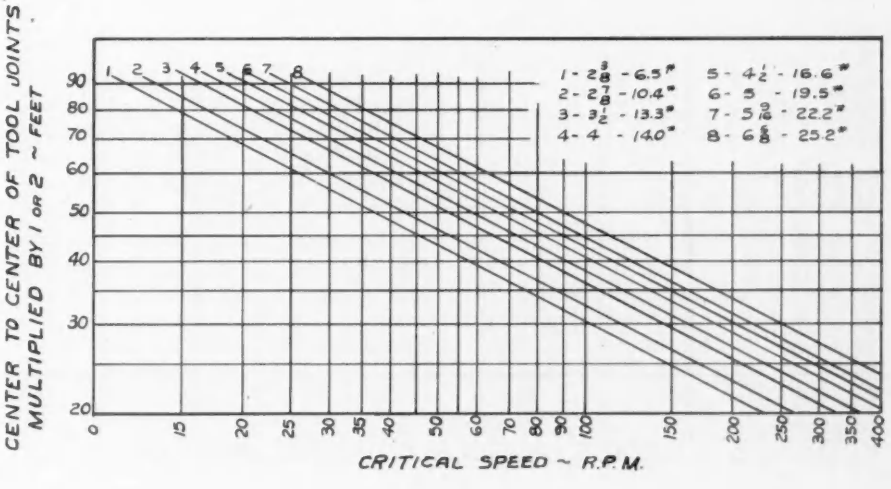

CENTER TO CENTER OF TOOL JOINTS MULTIPLIED BY 1 OR 2 ~ FEET
1 - 2 3/8 - 6.5#
2 - 2 7/8 - 10.4#
3 - 3 1/2 - 13.3#
4 - 4 - 14.0#
5 - 4 1/2 - 16.6#
6 - 5 - 19.5#
7 - 5 13/16 - 22.2#
8 - 6 5/8 - 25.2#
CRITICAL SPEED ~ R.P.M.

FIGURE 7

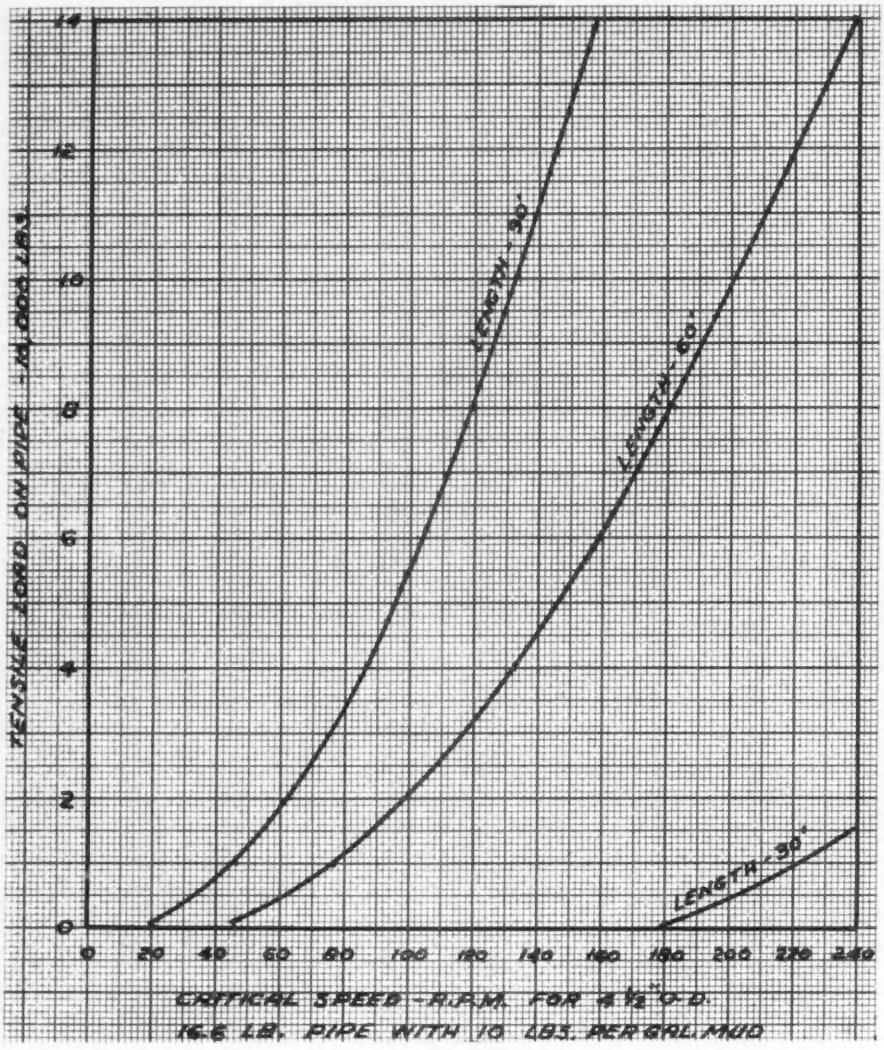


FIGURE 8

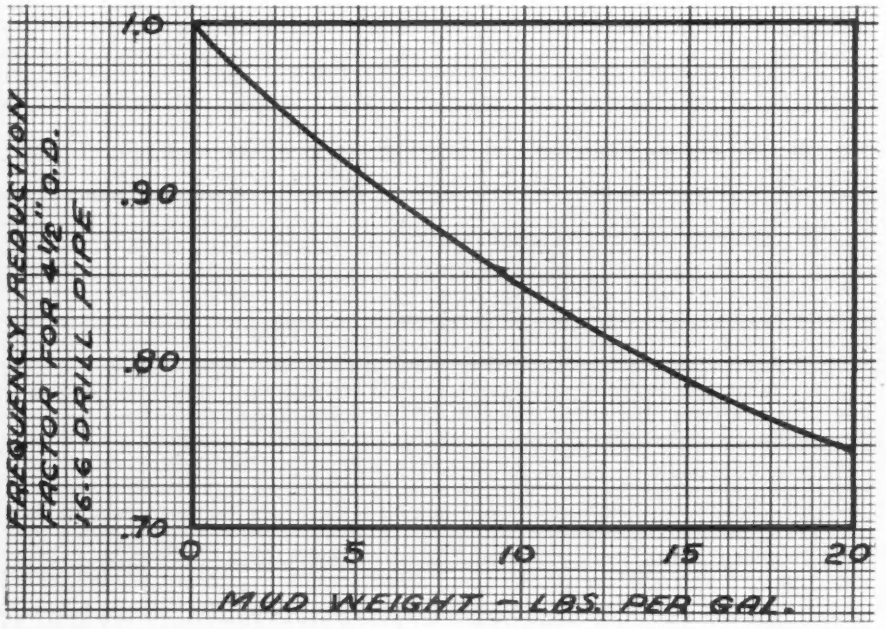


FIGURE 9

the three probable modes of vibration for 4½-inch outside diameter. Figure 8 shows 16.6-pound drill pipe rotating in ten pounds per gallon mud. The frequency reduction factor for 4½-inch O. D. drill pipe when operating in various weight drilling mud is shown in Figure 9.

In Figure 8 it will be noted that the critical speeds for lengths of 2 and 3 joints lie in the range of common rotating speeds and the critical speeds for vibrations in lengths corresponding to one joint occur at relatively high rotating speeds providing the pipe is not operating in compression. If the pipe is operated in compression; the single joint critical speed may occur in the range of common rotating speeds. Due to the length of the span over which bending occurs and the limiting effect of the hole wall it is improbable that dangerous stresses will be induced into the drill pipe when vibrations occur over lengths of two or more joints, as this condition will always occur at one or two points in the drill stem unless the rotating speed is very low this is fortunate. If it were possible to control the location of these vibrating joints with reference to formations with sloughing tendencies some cases of stuck drill pipe might be eliminated. This result could be accomplished if the tension load on the drill pipe could be accurately controlled.

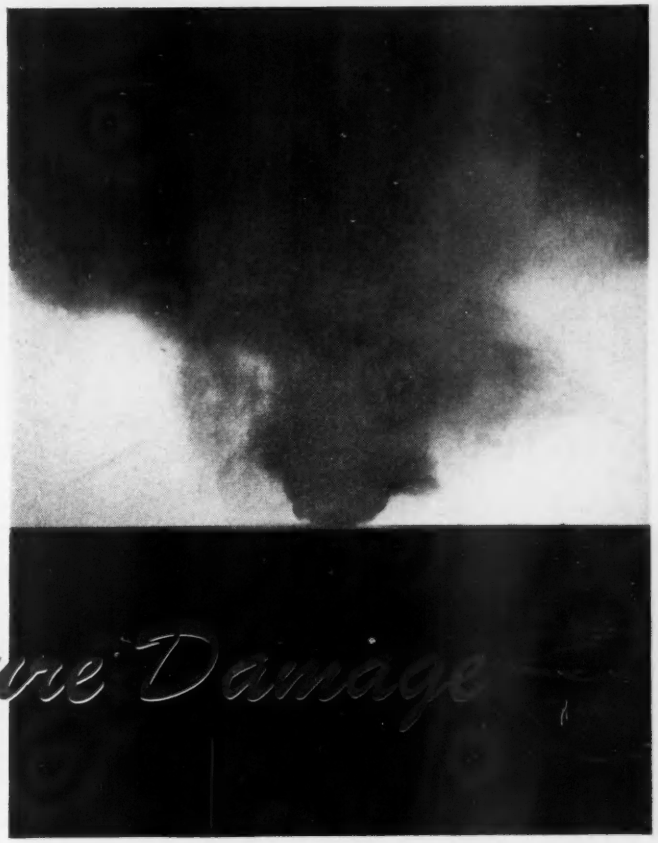
Selection of Speeds

Due to the high magnitude of the vibratory stresses which can be induced by vibrations over lengths corresponding to one joint, this critical speed should be avoided. These stresses will be high because the bending will be confined to individual joints. These dangerous critical speeds can be avoided by proper selection of rotary speeds and operating the drill pipe in tension. If the drill pipe is operated in compression, these critical speeds may correspond to practical rotating speeds and they will be difficult to avoid. When one joint starts vibrating in this manner it will cause adjacent joints to start vibrating. This action will subject the wall of the hole to a very severe pounding, which may promote lost circulation. Also, due to the violent action of the drill pipe in this section the mud flow will change from viscous flow to turbulent. This will cause the annulus circulating losses to increase in this section and this increase in circulating pressure may be sufficient to cause lost circulation.

REFERENCE

1. Hawkins, M. F. and Lamont, Norman. The Analysis of Stresses in Drill Pipe. 1949 Spring Meeting API.

Wave and Storm Factors in Offshore Structure Damage



THE method and data used to establish the path and wind field of the hurricane of October 3-4, 1949, are outlined in this paper. Computations of maximum wave heights which could have been experienced at the Ohio-Melben (joint venture of The Ohio Oil Company and Melben Oil Company) and Stanolind Oil and Gas Company offshore structures showed that in neither case did the crests of the average of the highest third of the waves exceed the top of the platform. However, the average of the highest 10 percent of the waves was sufficiently great that crests could have exceeded the platform height by about two feet for an hour at the Ohio-Melben site. There were probably about 36 such waves which would have gone over the platform base and would have produced a maximum horizontal dynamic pressure on a flat plate oriented perpendicular to the wave crests of 940 pounds per square foot. The maximum upward force on a horizontal plate at platform height would have been 85 pounds per square foot. The highest waves were from the south and south-southeast.

Damage By Waves

Aerodynamic forces resulting from the action of the wind upon the crew's quarters of the Ohio-Melben installation would exceed, in gusts, 14 pounds per square foot, tending to lift the structure off its base. It must be concluded, however, that the observed damage to this structure was probably due largely to the action of the few waves which exceeded the platform height.

It is concluded that although rather severe conditions were experienced in this storm, nevertheless, the theoretically worst possible conditions did not occur. These conditions would obtain only if waves break at the site, in which case the breaker height would be 46½ feet and the crest of the breaker would extend about 19 feet above the present platform (assuming a maximum storm tide of ten feet). The probable frequency of such an event would be once in 50 years.

CASE HISTORIES of hurricane damage to offshore drilling platforms are an invaluable aid to design and orientation of such structures. This preliminary report on oceanographic and meteorological factors involved in damage to offshore structures during the hurricane of October 3-4, 1949, prepared by the American Institute of Aerological Research, for Langham, Langston and Burnett, insurance counselors of Houston, as a part of a study of insurance factors in offshore drilling, is here presented through the courtesy of that organization.

Hurricane Wind Field and Path

In addition to the routine sources of data a large number of wind and barometric observations taken at half hourly and sometimes quarter hourly intervals were studied in determining the hurricane path and intensity. The supplementary stations reporting were: the U. S. Coast Guard Station and U. S. Engineers at Matagorda, Texas; the U. S. Coast Guard, U. S. Engineers, and Dow Chemical Plants A and B at Freeport, Texas; Hoskins Mound; Galveston Coast Guard Station; Bay City, Texas, City Hall, and several ship and aircraft sources. Analysis of these records and radar data supplied by Dow Chemical Company indicated that this hurricane passed inland across Cedar Lake and continued northward, passing between Brazoria and Lake Jackson, Texas, along

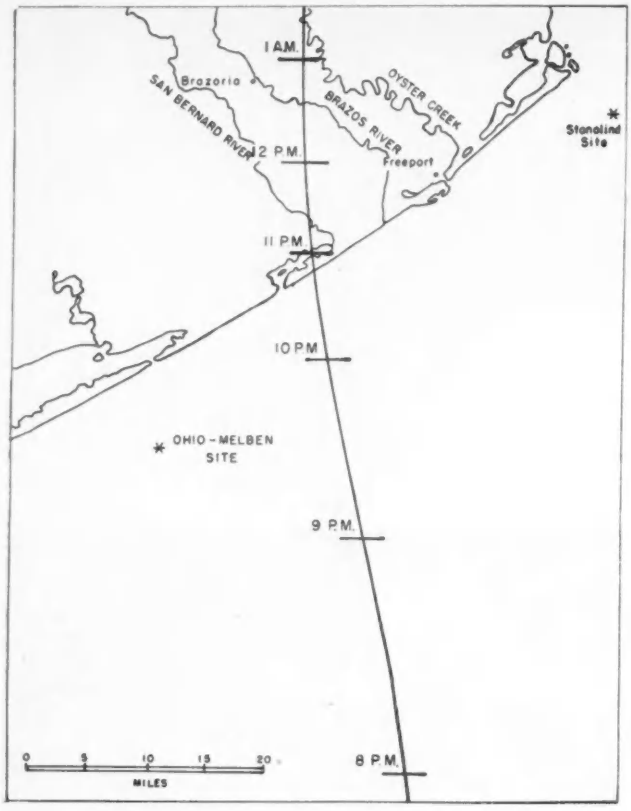


FIGURE 1. Hurricane path.

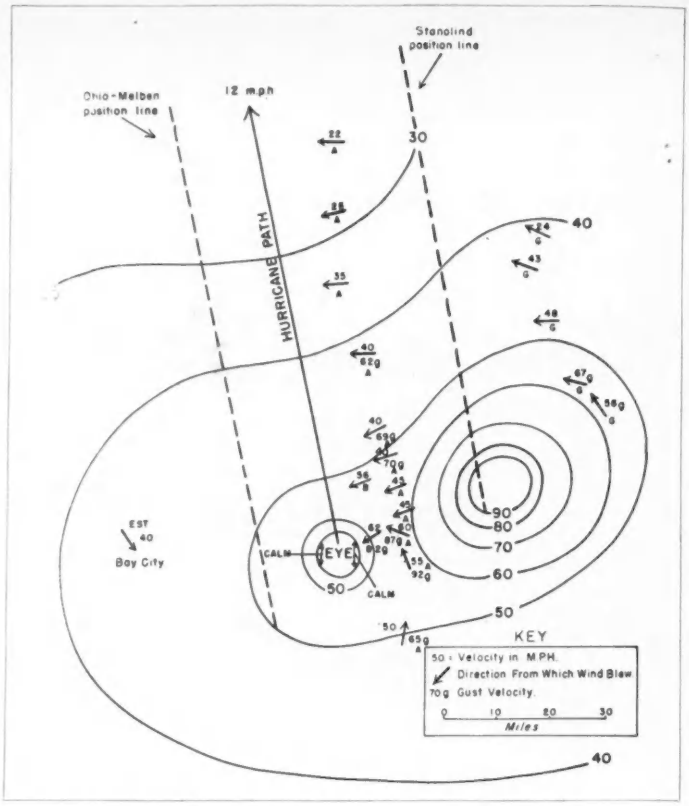


FIGURE 2. Wind velocity field (mph) around hurricane.

the trajectory shown in Figure 1. The center passed approximately 15 miles to the east of the Ohio-Melben platform site and about 29 miles to the west of the Stanolind site.

To compute wave characteristics at the two structures, it is first necessary to know the distribution of surface wind velocities within the hurricane. All available wind reports during the storm were plotted according to their position with respect to the hurricane center as shown in Figure 2. The notation A refers to reports from the Dow Chemical Plant A, B refers to those from Dow Chemical Plant B, and G to those from Galveston. Using these plotted data and the known pattern of winds around a hurricane,[1] it was possible to construct isopleths of wind strength (lines of equal wind velocity) with a fair degree of accuracy. The wind direction field was also determined through use of the available data and the ideal pattern.

Sea Condition at the Two Sites

A technique for accurately forecasting wave conditions from the wind field was developed during World War II.[2,3] Through the application of this technique to a 40-year archive of weather charts, "hindcasts" of wave conditions in the Gulf area have been made and summarized[4] to give the frequencies with which various critical wave conditions can be expected.

In this investigation the technique was used to predict wave characteristics at the Ohio-Melben and Stanolind locations in the absence of actual reports during the height of the hurricane. By the selection of a number of "fetches" over which winds of a certain average strength blow for a certain time, the various combinations of wave characteristics at the two sites were ascertained. Because of the trajectory and speed of this storm, it was possible for a set of waves to travel along with the storm in its right hand sector for a considerable period of time. Due to this, the waves continually increased in size as energy was imparted to them by the wind. At first the group velocity of the smaller waves was somewhat less than the storm velocity. However, as they increased in size and in velocity, they ultimately moved out ahead of the storm. Since these waves had traveled through a long distance before reaching the offshore installations, their period was great and they had the character of swells. Some of the swells running ahead of the storm had a 20-foot amplitude with an 11-second period when they reached the Ohio-Melben site during mid-afternoon of October 3. By 9 p.m. the wave height had increased to 27 feet with a period of 10 seconds. At 10:45 p.m. the height was reduced to 21 feet with a period of 9.7 seconds. At the Stanolind site swells running ahead of the storm reached 15 feet at 4:30 p.m. with a period of 11.2 seconds. The highest waves of 10.6 second period and 26 feet amplitude occurred at 10:30 p.m. At 12:45 a.m. on October 4 the wave height was reduced to 16 feet with a 9.9 seconds period. None of these wave crests reached the platform height at either location in question.

Wave Heights

Although the Stanolind rig lay directly in the path of the maximum winds of the hurricane (see Figure 2), the wave heights at the Ohio-Melben location were greater than those at the Stanolind position. This may be explained as follows:

A study of the bottom contours and a consideration of refraction effects indicated that deep water wave crests approaching the Ohio-Melben site from the south and southeast were increased in height. The reverse process occurred in connection with the waves approaching the Stanolind site from the south. This effect is shown in Figure 3. Two sets of wave crests and orthogonals are shown, each representing the manner in which wave crests move in under the worst possible conditions to each of the two sites. At the Ohio-Melben site the deep water wave height is increased by

a factor of 1.04 whereas at the Stanolind site it is reduced by a factor of 0.85.

Steep, short period storm waves from an easterly direction were undoubtedly superimposed upon the longer period swells as the center of the storm approached the areas of interest. However, due to refraction effects, these were considerably reduced in magnitude, with the result that a choppy sea occurred but the long period swell component from the south to south-southeast was the most important feature.

Significant Waves

The normal technique used in hindcasting waves is based entirely on the concept of "significant waves" which are the average of the highest one-third of all waves present. Tests have shown that this is the height the average experienced observer records. Since there is a spectrum of wave heights, a few waves will be higher than those indicated by this technique. A recent analysis of Pacific Coast wave records has shown that the highest 10 percent of the waves present have an average crest which is 1.29 times the average of the highest third.[5]

Since the highest waves computed above by the normal technique existed probably not more than an hour and since their period was about ten seconds, there were about 360 passing the structure during the hour. Ten percent of this would be 36 waves which could exceed the maximum values given above by 29 percent. Thus, at the Ohio-Melben rig one might expect about 36 waves to attain a height of 35 feet and at the Stanolind rig a similar number to attain a height of 33 feet. The extent to which the wave crest exceeds the mean water level depends upon the wave steepness and ranges from a half of the wave height in the case of very flat waves to three-quarters of the wave height in the case of breakers. To determine the height of the crest above bottom, it is necessary to consider, in addition, the storm tide. From the reported storm tides along the coast and known facts regarding them, it is estimated that a storm tide of six feet was possible at the Stanolind site and not more than five feet at the Ohio-Melben site. It appears that the 35-foot waves at the Ohio-Melben site would have had a crest of 24 feet above the mean water level and at the Stanolind rig the 33-foot wave would have had a crest 22 feet above mean water level. Considering the storm tide, the platform at the Ohio-Melben rig (27 feet above normal mean water level) would be only 22 feet above the storm mean water level and therefore the crest of the highest 10 percent of the waves would exceed the platform height by two feet. At the Stanolind site the crests would be under the platform height by several feet.

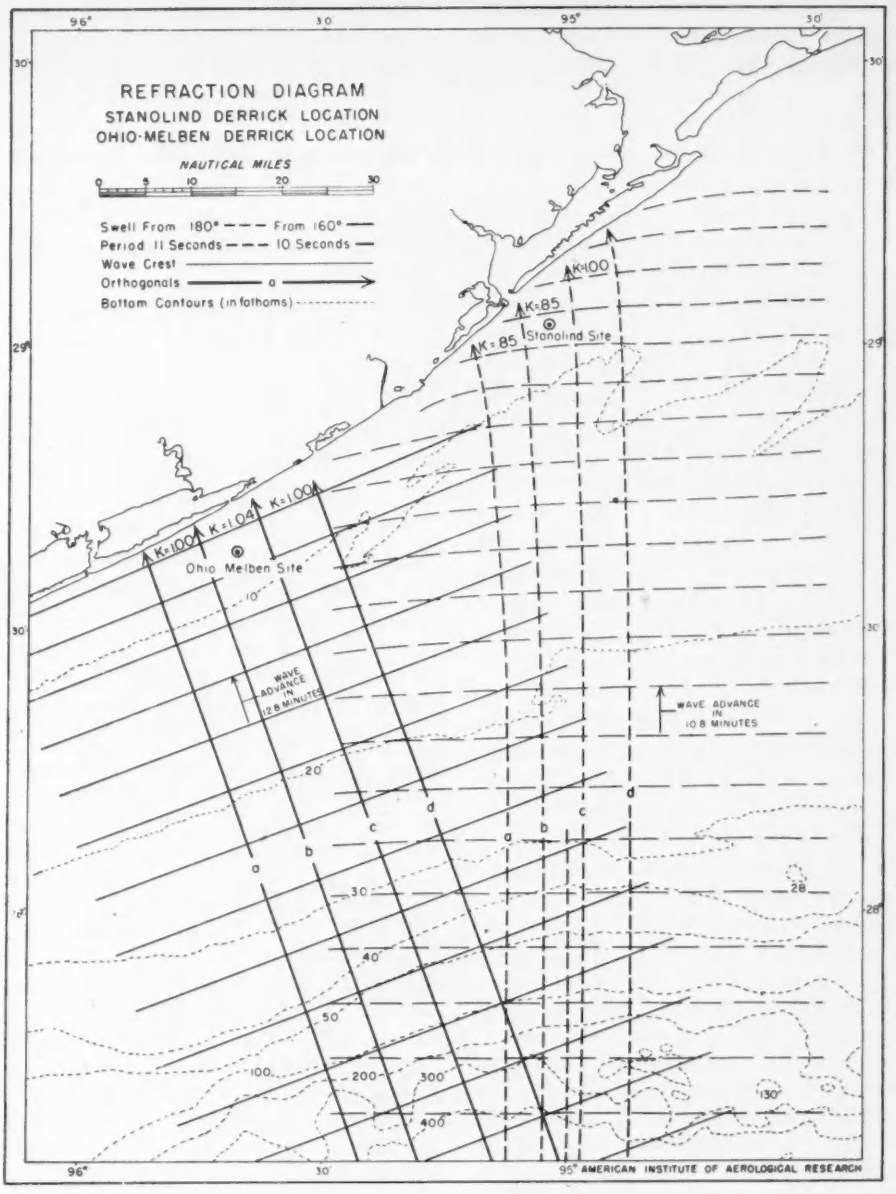


FIGURE 3

Wave Forces at Ohio-Melben

Since it is desirable to estimate the maximum forces which were exerted on the Ohio-Melben structure in order to explain the observed damage, it will be well to deal with the forces due to the highest 10 percent of the waves at the site. Using the solitary wave theory to obtain particle velocities in accordance with the technique developed by Munk[6] for determining wave forces, the maximum horizontal dynamic pressure on a vertical flat surface perpendicular to the 35-foot wave crest at the Ohio-Melben site would be 940 pounds per square foot. This is at a height of two feet above the platform base. At this elevation the vertical force on a flat plate would be zero, and at the elevation of the platform, the maximum horizontal force on a flat plate would be 850 pounds per square foot and the vertical force about 85 pounds per square foot. For comparison purposes, the horizontal force exerted on circular piles at 27 feet above normal mean water level would be about 150 pounds per square foot.

Maximum vertical force at the platform level would occur just before the crest arrived, while the maximum horizontal force would be experienced at the crest. These computations are based on the steady-state solution developed by Munk and do not consider acceleration forces. Acceleration forces are be-

lieved to be of about the same magnitude as the steady flow forces and about 90 degrees out of phase, therefore the maximum values given above may be about 40 percent too low.

Only the average of the highest 10 percent of waves was considered in this analysis, as it was estimated that about 36 such waves occurred. However, it is possible that a few of these may have exceeded the platform height by as much as four to five feet. Any of these waves would have broken on the southeast edge of the platform and little if any of the water would flow completely across the top of the platform.

Too little information is available to consider in any detail the magnitude of the forces required in order to produce the observed damage. Therefore nothing can be done at present beyond the presentation of the above figures which indicate what appears to be the worst possible condition which could have occurred in this particular storm on the basis of the computation schemes now available. It might be well, however, to point out that the worst possible conditions which could theoretically occur at this site did not obtain in this particular instance. Allowing for a maximum possible storm tide of ten feet in the stated depth of water, breakers could occur in which the breaker height was 46½ feet. These breakers would extend about 36 feet above the storm mean water level, which in this case would be 60 feet and therefore would exceed the platform height by 19 feet. Waves higher than this would break well offshore from the site and little damage would be suffered in the resultant surf. It therefore may be remarked that the platform height was not sufficient to meet the worst possible conditions that could theoretically occur at the site. On the basis of previous studies of wave characteristics in this region it appears that this event may occur about once in 50 years.

Although there exists a possibility that the dense cluster of piles beneath the Ohio-Melben structure could act as a breakwater causing waves to splash upward against the platform, insufficient evidence based upon model tests is available to form an opinion.

Aerodynamic Forces

Photographs of the Ohio-Melben rig prior to the hurricane show that the crew quarters consist of two one-story structures, each with a curved roof. From the shape of these roofs it would seem highly probable that aerodynamic forces produced by strong wind flowing past the structure could produce considerable lift, in particular on the curved roofs. The lifting force exerted on any body is:

$$C_L \times \tfrac{1}{2} \rho V^2 S$$

where C_L is the lift coefficient and depends upon body shape, $\frac{1}{2} \rho V^2$ is the pressure force due to a wind of velocity V in air of density ρ, and the force acts on an area S. C_L is estimated from known wind tunnel data. Steady winds of 50 to 60 miles per hour blowing over a curved surface in the manner shown in Figure 4 produce a lifting force on the roof alone of 6 to 7 pounds per square foot with the gusts which were probably present doubling the lifting force. (This force increases as the square of the velocity.)

In addition to the wind forces there is a lifting component applied from below on the flooring of the platform. The waves encountered at the site were of trochoidal form with crest angles not far from the critical limit of 120 degrees. Wind blowing over such a crest would be thrust upward toward the platform impinging upon it an angle of as much as 30 degrees as indicated in Figure 4. The lifting force on the structure due to these combined effects might have been sufficient to remove the crew's quarters from the pilings and blow them into the water. In view of the fact, however, that the dynamic pressures resulting from wave action are so much greater and because a few of the waves would have reached the floor of the platform, it is believed that wave action may have been largely responsible for the destruction of this structure.

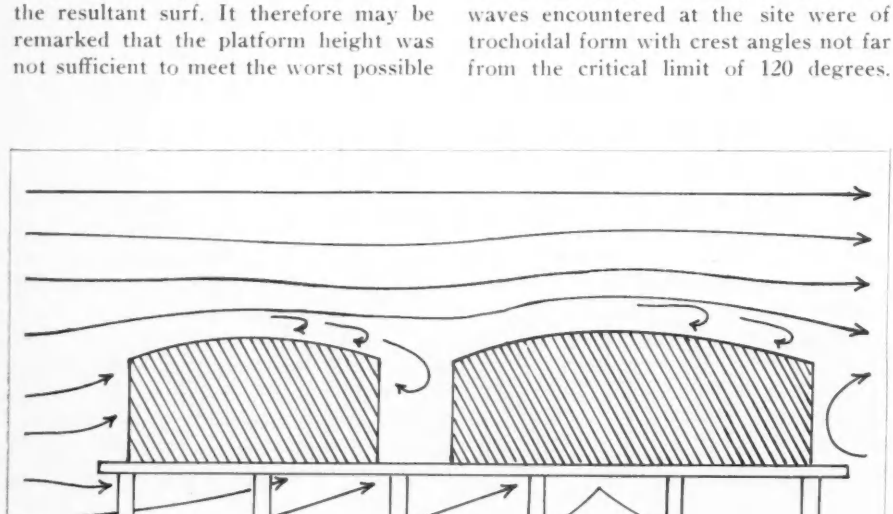


FIGURE 4. Wind flow around Ohio-Melben crew quarters.

Conclusion

Analysis of the available data indicates that a few waves definitely broke over the Ohio-Melben platform and affected at least the southeast side of the platform, producing a maximum horizontal dynamic pressure on a flat plate of at least 940 pounds per square foot and vertical dynamic pressure of at least 85 pounds per square foot. It is believed that these forces were responsible for the major portion of the destruction observed, although aerodynamic forces acting on the crew's quarters might also have contributed to the destruction. The worst possible conditions which could have occurred at the site were not experienced in this storm. With a maximum storm tide of ten feet, waves of sufficient height to break would be 46½ feet high and their crests would extend 19 feet above the platform.

The meteorological and oceanographic analyses presented herein were conducted by R. D. Elliott and Paul Horrer under the direction of Dr. Irving P. Krick. Norman MacDonald of the American Institute of Aerological Research, Pasadena, California, aided in the collection of data for this study, supplementing those obtained through normal channels.

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[4] American Institute of Aerological Research, Oceanographic Surveys No. 1 & 2, prepared for Shell Oil Company; and Oceanographic Conditions Pertinent to Engineering Problems in Areas off Timbalier Bay and Pass a Loutre, prepared for the California Company.

[5] Wiegel, R. L., An Analysis of Data from Wave Recorders on the Pacific Coast of the U. S., Technical Report HE-116-246, Fluid Mechanics Laboratory of the University of California, 1949.

[6] Munk, W. H., Wave Action on Structures. Tech. Pub. No. 2322, Petr. Tech. AIME, 1948.

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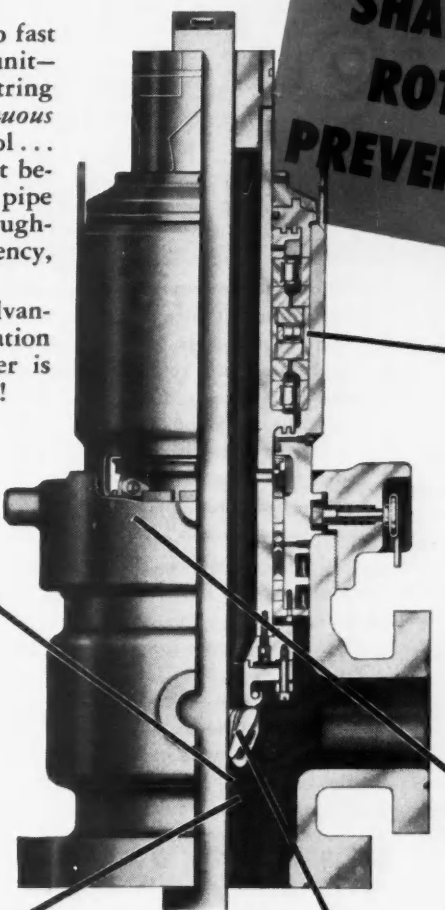

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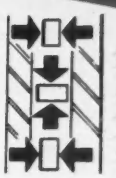

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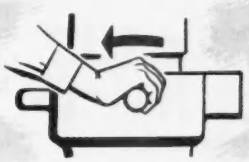

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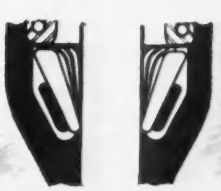

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Care and Handling of Cable Tool Wire Lines

By E. L. KLINGLER
Colorado Fuel and Iron Corporation

THE AUTHOR discusses the more common causes of wire line failure, and points out means for avoiding the conditions which contribute to excessive wear. Tapered lines, for conditions below 6000 feet, are advocated, but only after special design to fit the conditions of the hole and drilling requirements.

THE cable tool wire line is a slender metallic thread connecting the beam and the drilling tools several thousand feet below, and as such performs an all-important function in drilling. The drilling bit is not merely dropped against the formation with the up and down motion of the beam, but through the elastic, spring-like action of the line, is caused to strike a solid blow. During the drilling cycle the line elongates and contracts, accompanied by alternate letting out and taking up of the rope lay. Proper adjustment by the driller of the stroke and motion results in the maximum force being transmitted to the tools through the drilling line.

Several things can happen to a wire line during installation and service which may interfere with its ability to operate at top efficiency, or may cause short service, resulting in higher wire line costs, unsatisfactory drilling performance, and lost time.

Some of the conditions which occur are beyond the control of the operator, but many are within his power to prevent or alleviate through the exercise of a reasonable amount of care. Drilling lines are designed and built to withstand to the greatest degree the destructive factors of abrasion, bending fatigue, corrosion and loading normally encountered in drilling. However, the success or failure of a cable tool line to do the job depends in large measure on the care given the line during installation and use. The suggestions on care of the cable tool line which follow are economical of time and effort and will pay dividends in more satisfactory wire line service.

The following paragraphs cover a number of abnormal conditions which may develop in the line, how they may be identified, and what measures may be taken by the operator to help prevent them.

Abrasive Wear

Uniform abrasive wear, the wearing away of the crowns of the wires through contact with the hole, crown sheave and shaft, is a normal result of drilling, and its severity depends upon the abrasive conditions present. If a line wears out uniformly, it must be considered to have given good service under the conditions of operation. However, non-uniform or spotty wear is not normal, and is very destructive to the line.

Non-uniform wear usually occurs in one or more of the following forms:

1. Doglegs
2. Kinks
3. Spiral Wear
4. High Strands

Doglegs

Doglegs are responsible for more cases of unsatisfactory wire line service than any other single condition. A dogleg is a permanent short bend or bow in the line which does not straighten out under load. The outside of the bend, being prominent, is subjected to excessive wear, while the inside of the bend, being held away from contact with the hole, receives very little wear. A dogleg can be readily identified by excessive wear on one side of the line over a short section, with little or no wear directly opposite the worn section.

Wear on the outside of the bend progresses at a much faster rate than would normally occur on a straight section of line. After a dogleg has been placed in the line and wear has progressed to the stage where the condition is found on inspection of the line, the only remedy is to cut out the damaged section and splice, otherwise the wear will progress until the metal removed by abrasion reduces the strength of the line to the point where it parts under tensile load, and a fishing job results.

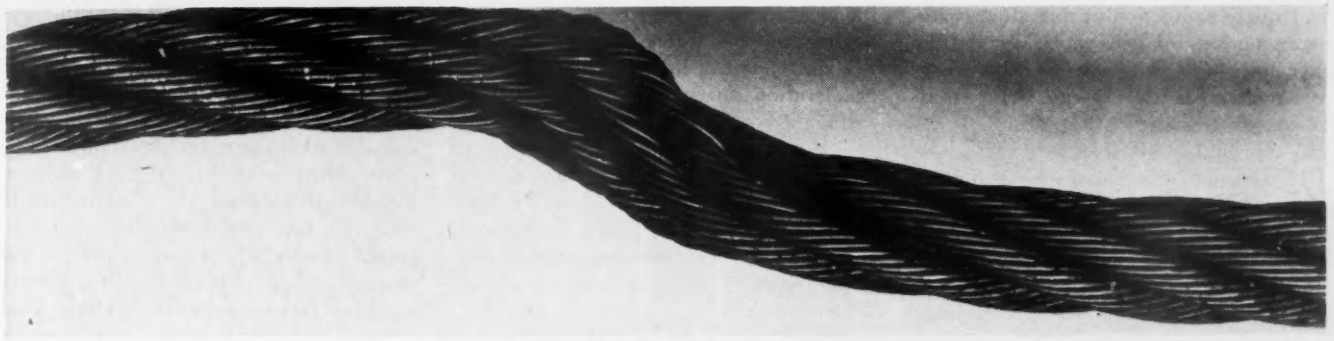
To prevent the formation of doglegs, extreme care should be taken during installation of the line that no sharp bends are placed in it. The line should be installed on the shaft tightly, with uniform tension. It should be spooled evenly and should not be permitted to pile up or crisscross on the shaft. Dividers should be properly designed and maintained in perfect condition so that the line passes from the reserve to the active side with no sharp bends.

Doglegs sometimes occur within 50 to 100 feet of the tools for some reason not definitely known. This section of line should be regularly inspected, and if doglegs occur, they should be cut off and the line re-socketed.

Kinks

A kink is caused by a loop being thrown in the line and pulled through. This results in a short spiral deforma-

Uneven wear resulting from dogleg.



Kink, before being subjected to wear.

Spiral wear.

tion accompanied by a slight lengthening or shortening of the rope lay, depending on the direction the loop is thrown. A kink wears in a short spiral for about one turn around the line, the inside of the spiral usually showing little wear.

Kinks are usually caused by slack being allowed to develop in the line as it is being installed, permitting a loop to be thrown in the line. If this loop meets some obstruction, or if tension is applied, it is pulled through and a kink is formed. During installation, be sure that uniform tension is constantly maintained between the rope reel and the shaft. If a loop is formed, it should be thrown out by hand and the slack carefully taken up before proceeding.

Spiral Wear

If a wire line is pulled around an obstruction such as a sill, rig girt or small snatch block, it will assume a spiral form. In drilling, the outside of the spiral assumes a greater portion of the abrasive wear. Due to the unequal distribution of wear on the line, its service life is considerably reduced.

When installing the line, make certain that it is completely in the clear from reel to shaft, and does not pass around any obstruction. If a block is used to deflect the line, use a tubing block of adequate size which turns freely.

High Strands

A high strand condition is one in which one or more strands in the line assume a greater proportion of wear. This excessive wear on one or more strands is usually present in the entire length of line which has been in the hole.

The cause of high strands, which is a condition occurring almost exclusively in cable tool lines, has never been definitely established. However, probably due to improved methods and equipment adopted by both manufacturers and drilling operators, high strands have become relatively rare. Precautions which may help reduce the chance of high strands are maintaining the drilling clamp liners in good condition, and seizing the rope adequately before cutting when socketing. Slipping the line through the clamps, particularly at deeper depths, may cause distortion and disturbance of balance in the line, favoring the development of a high strand condition.

Bending Fatigue

A cable tool line is subjected to bending fatigue in winding on the shaft and passing over the crown sheave, as well as by the flexing of the wires throughout the length of line in the hole during drilling. Although bending fatigue is secondary to abrasive wear, a combination of the two ultimately results in breakage of the wires on the crowns and discard of the line. Drilling under conditions which cause whipping or vibration causes added fatigue. Under certain conditions whipping of the line against the casing or formation may result in work-hardening or transformation of the wire surface, greatly decreasing the fatigue life. When used on a spudder the line is subjected to repeated bending over the sheaves during drilling.

Bending fatigue is greatly increased if rusting or corrosion is present, due to the restriction of the free movement of the wires as the line bends.

On the standard rig, increase in the diameter of the shaft and crown sheave will reduce bending fatigue. When drilling in hard formation with a spudder, resulting in a short section of the line being subjected to continued operation over the spudder sheaves, a few feet of line should be cut from the bottom of the line at frequent intervals to change the position of the rope and bring a new section of line in the sheaves.

Corrosion

In some areas, corrosion is a minor factor in cable tool line performance, while in others it is the most destructive. When severe corrosive conditions are present, reduced wire line service is inevitable, although certain precautions may be taken which will in some measure reduce the effect of corrosion. The most common means of combatting corrosion is through the use of a galvanized line, which is very effective in some areas. Adequate lubrication applied to the rope during its manufacture offers protection; however, this initial lubrication must be supplemented by regular applications during service if continued protection is expected.

Many wire lines are ruined because of

About the Author

E. L. (GENE) KLINGLER graduated from Bucknell University, Lewisburg, Penn., in 1929 with a B.S. degree in Chemical Engineering and entered the wire rope industry shortly afterwards. Since January, 1946, he has been with The Colorado Fuel and Iron Corporation, first as sales engineer at the Wickwire wire rope mill at Palmer, Mass., and later as assistant manager of wire rope sales. Since 1949 he has been at Houston with the Mid-Continent area as his field.

inadequate protection during storage between periods of use, especially if they have been operated in wells where corrosive elements are present. Before periods of idleness, the line should be cleaned and thoroughly lubricated.

In addition to seriously reducing the life of the line, corrosion affects the elastic quality of the line by preventing the free movement of the wires within the line structure, resulting in a "dead" line with poor drilling action. Proper lubrication during use and before idle periods does much to prevent corrosion between the wire surfaces within the line, resulting not only in longer life but also better drilling performance.

Loading

As a well goes deeper the load on the line steadily increases due to the greater weight of line suspended in the hole. When drilling at approximately 6000 feet or less the load is not sufficiently high to cause any harmful effects in the line, but as the depth progresses below 6000 feet the effect of loading becomes increasingly important. With an increase in load there is an increase in the untwisting moment caused by the spiral path of the strands in the line, and an increase in the pressure of the strands against the fiber core. Below 6000 feet the static load of line and tools plus the acceleration force in drilling may be sufficient to cause an elongation of the rope lay and the failure of the core to support the strands, in a section near the top of the hole where the load reaches a maximum. The consequent distortion of the rope structure results in accelerated deterioration along this section.

Since the greater portion of the load is the weight of the line itself, the most logical and direct solution is to reduce the weight of the line by tapering.

A seven-eighths-inch diameter 6 x 21 filler wire plow steel fiber core line drilling at 8000 feet with tools weighing 2500 pounds will operate under a safety factor, based on static load, of 22.4 at the tools and 4.5 at the top of the hole. By the use of a properly designed tapered line, a minimum safety factor of 6 or more can be maintained, with an overall reduction in the total weight of the line. The resultant increase in safety factor at the top of the hole eliminates the damaging effects of overloading encountered in a one-diameter line.

Secondary advantages gained are an over-all reduction of load, requiring less power in drilling and coming out of the hole, and less wear on brakes and other equipment. In addition, the use of a tapered line will often permit the spooling of a longer length of line on the shaft, which coupled with the reduced weight will increase the effective depth range of the equipment. This may be of importance where it is desired to use smaller, more portable drilling equipment in remote or hard-to-reach locations.

A tapered line should be specially designed and manufactured to meet the particular conditions of depth and load for each application, and should not be installed on the rig before reaching the depth where its use becomes necessary and full benefit may be derived from it.

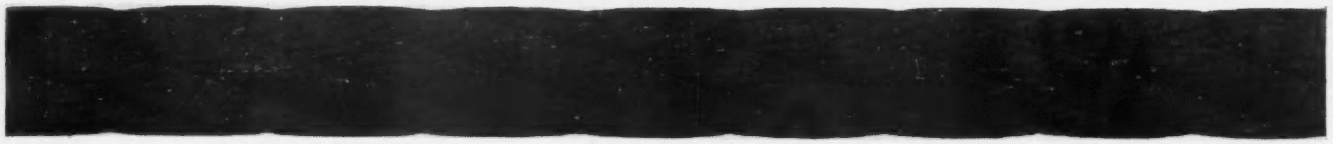
It is recognized that the operator's prime object is to make hole, and economics control the amount of time and effort that can be expended in taking care of the drilling line or any other part of the drilling equipment. However, a little additional care and the following of the simple precautions outlined here will be reflected in less lost time, more efficient drilling performance, and lower wire line costs.

Uneven wear resulting from high strand.

Uniformly worn line.

Broken wires caused by a combination of wear and fatigue.

Corroded rope, showing deep etching resulting from prolonged exposure to acid condition.



Heavily rusted rope.

The well on the left is an example of where two additional strings of protective casing were necessary — one to protect a zone of rock salt and the other to protect a sloughing shale. My-Lo-Jel Mud eliminated the necessity for this extra casing.

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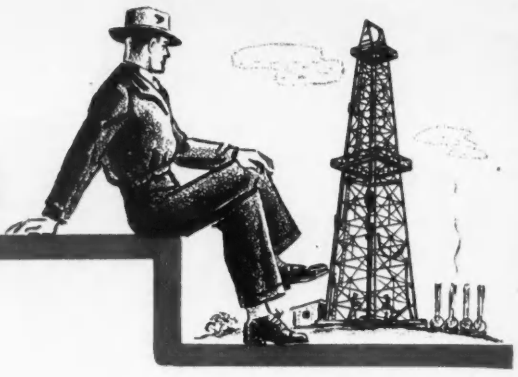
Sitting on a Well



By C. A. CASWELL
Consulting Geologist

THE IMPORTANCE of close and continued observation of a drilling well, not only by the geologist or engineer from the company but also by every man of each crew is stressed by the author. He outlines some of the cases in which a producer may be lost through lack of attention to details, and lists some of the salient points to be watched.

WELL watching, or "vertical wildcatting," is not a one-man job any more than is the "horizontal wildcatting" by which the location is picked. If your job is to find oil in drilling wells, there is more to it than just running samples. You can't watch a well from the nearest hotel room!

Every individual around the rig involved in the operations from the time the bit first breaks through the grass roots until the well is finished is a well-watcher, in addition to his other duties, whether or not he knows it. And the amount of oil per foot drilled that any company finds will depend upon how well all the personnel realizes this.

As a matter of fact, the discovery of an oil sand in a drilling well depends upon so many factors, both mechanical and geological, that it requires the closely coordinated efforts of all the personnel involved in the operation to find it. The reason for this is that, due to the usual organizational setup, some of these factors will be under the control of one man, while others of equal importance will be under the control of some other person. Unless these various units work together as a closely coordinated team, they are liable to end up in the position of a team of mules between two haystacks. They will be pulling against one another to such an extent that neither gets any hay.

In this case there are two desirable stacks of hay, or objectives, involved. The first is making hole as fast as possible, and the second is finding oil. And yet, in many cases, it will not be possible to have both at one and the same time. This problem of getting all the people involved to working together and headed in the same direction is the first that must be solved in watching for oil.

Of course, the more efficient companies realize this and point their efforts toward finding oil as the priority mission. Thus, their personnel are instructed accordingly and the well-watcher finds that his first problem is already solved.

In the rare cases where this may not be true, it is well for the geologist or engineer who may have to watch drilling wells to consider some of the effects drilling techniques may have on the discovery of oil sands. They are, of course, far too numerous to be completely covered in an article of this length. Furthermore, since the problem is essentially one of organization and coordination, there is much overlapping. Nonetheless, for the sake of convenience, an attempt will be made to discuss, under separate headings, some of these factors.

THE DRILLING MUD: Too often the problem of mud control is approached solely from the standpoint of the effect the mud has on the rate of drilling, without realization of the relation existing between mud condition and the discovery of oil sands.

While hole is being made, the first indication of the presence of a sand will usually be a drilling time break. For this reason, the minimum allowables for mud characteristics are those that will give clear drilling breaks between sands and shales. Furthermore, per foot drilling time should be kept on record so that these breaks can be picked up by the driller as soon as they occur.

In addition to this requirement, the mud must be in good enough condition to bring the samples cleanly to the surface and not allow them to be mixed in the rising mud column due to excessive elutriation or cavings from the portions of the hole already drilled.

In southern Oklahoma, for example, and especially in the Permian, Pontotoc, and Upper Pennsylvanian sections, this means a mud that ranges somewhere between 9 and 10 pounds in weight and 30 to 40 seconds in viscosity.

Such a mud will give a 25 percent to 50 percent differential between the drilling time of shales and sands. It should be added that when such a drilling time drop occurs it is necessary to circulate up a sample to the surface so as to determine what caused the time drop. And, of course, it is preferable to do this before drilling all the way through the soft spot. A good general rule is not to go more than three or four feet into a sand before stopping to circulate.

Unfortunately, a sand may not always be recognized by a drilling break. In some instances, a sand will drill at the same rate as shale, or it may drill much more slowly than shale. One oil-producing sand in the Carter-Knox field of Southern Oklahoma drills at 25 to 80 minutes to the foot, yet the shale above and below it takes only 15 to 18 minutes.

Under such conditions, close attention to sample returns as they arrive at the surface will be the only indicator of the presence of oil. The sample catcher should always check for an odor before washing the sample, and watch for oil or gas bubbles on the surface of the water in the wash bucket. Should either of these conditions occur, the geologist should be notified at once.

Here again mud condition plays an important part. Should the time lag in arrival of samples at the surface be too great, due to mud of poor quality, the presence of a possible oil sand may not become known until too late to do anything about it.

Another serious difficulty may develop when the water loss of the mud is too high, or in those cases where the hole is "clear-watered" down. A rather poorly cemented, unconsolidated, porous sand may be flushed of its oil content before arriving at the surface.

This is especially true where such sands contain lighter, high gravity oils. Under such conditions, even a circulating sample will be of little use in determining the advisability of coring or testing.

An example is the West Cache Creek

area of Cotton County, Oklahoma. The producing sand occurs at about 1250 feet and is coarse, unconsolidated, conglomeratic. When this sand is circulated to the surface and if the mud is in good condition, about 8 to 10 minutes after circulation has started, a slight show of oil bubbles breaking in the mud will be noted. There will be a fairly strong odor around the flow pipe and in a handful of unwashed sample. This condition will last for approximately five minutes, after which there is no show to indicate the presence of oil, since the loose sand grains in the sample show no stain. The sand bed, on an electric log, looks like a water sand (Figure 1).

If the mud is not in good condition there will be no drilling change to indicate a sand—and even if the sand is picked up by an alert driller, there will be no show in the circulating sample.

If the sand is drilled through without circulating, or if someone is not at the sample box during the critical five-minute period while circulating, there will be nothing to tell the operator he has passed through a sand that will produce 80 barrels a day of 40-gravity oil.

In general, a good drilling fluid should have properties in the range shown below:

- Solids—30 to 35 percent.
- Water—60 to 75 percent.
- Weight—9 to 12 pounds per gallon.
- Viscosity—30 to 40 (Marsh funnel 500 cc.).
- Sand content—Less than 2 percent by volume.
- Wall building test—(using 100-pound tester)
  - Filtrate ("Water loss")—10 to 20 cc./hour.
  - Filter cake thickness—2/32 to 4/32 inch.
- pH value—8 to 10
- Gel strength—
  - Initial—6 to 14 lb./100 square feet.
  - 5 minute—12 to 24 lb./100 square feet.
- Salt—80 to 160 grs./gal. (Salt content must be kept low when conditioning mud prior to running an electric log. An excess of salt in the mud can ruin the value of an electric log. Should shallow salt water sands be allowed to contaminate the drilling mud, it may be necessary to run an entirely new batch of mud to get a hole in shape to run an electric log and get favorable results.) See Figure 2.

In general, mud that will maintain the hole in the best condition will make it easier to recognize an oil sand during drilling operation, although in some cases it may be necessary to have a better quality mud than would normally be required to keep the hole in drillable condition. Of course, this will usually slow down the rate of drilling.

In areas where the Permian-Pontotoc red beds overlie the older formations, these shallow "red beds" will usually increase the weight and viscosity of the drilling fluid. This, however, does not eliminate the need for proper mud control. The wise operator will keep in constant contact with his mud engineering service company whose representative is available at all times to give necessary and generally free advice on prevailing mud conditions in the bore hole.

It is important to realize, however, that the buildup of this "native mud" takes some time. And since the rate of drilling in these shallow beds is usually very fast, oil sands above 1500 to 2500 feet in depth often will be missed entirely if complete dependence is placed on only the buildup of native mud. Four or five sacks of gel forming material

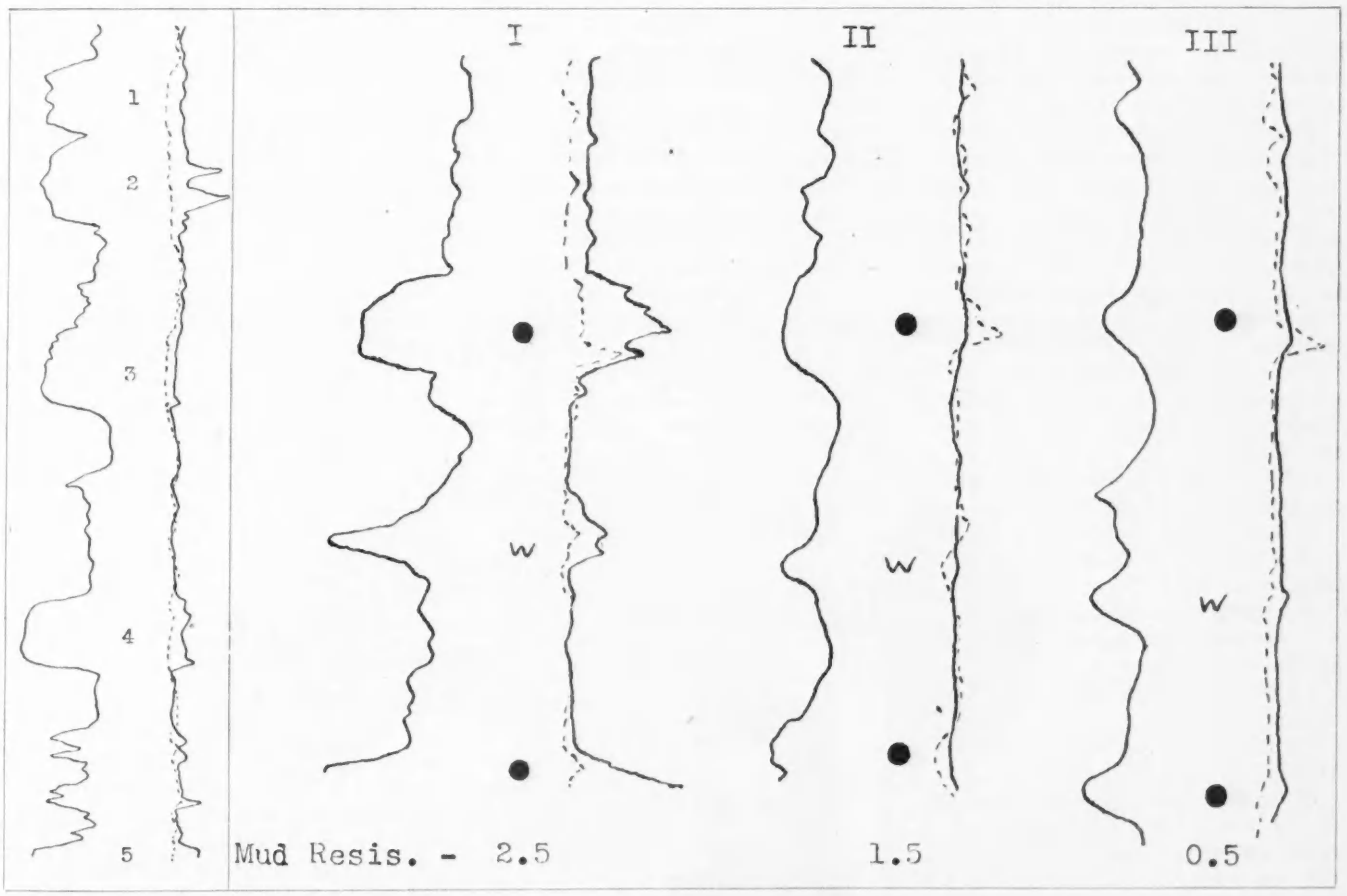


FIGURE 1 (left). Typical electric log from West Cache Creek field. Question: If this were your wildcat well, where would you set pipe? Sands 4 and 5 are producing oil sands. In some instances, the shaly sand zone between them is developed into a good sand body. In those cases, it too is a water sand similar in appearance to the others. Sand 4 is the coarse sand referred to in the text.

FIGURE 2 (right). Electric logs showing effects of contamination of drilling mud by salt water sands. Note how curves smooth out and details fade as mud resistivity decreases.

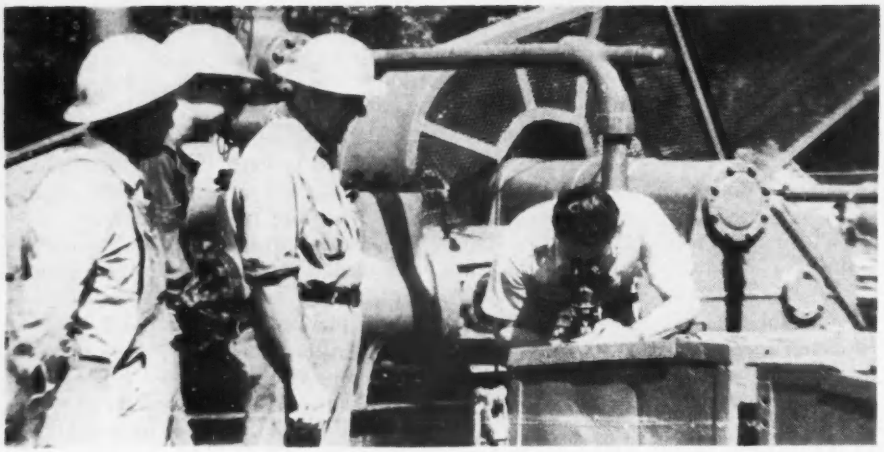


FIGURE 3. Geologist examines drill cuttings while members of the drilling crew stand by. Teamwork between geologist and drillers is an essential function of "well sitting," especially on wildcat locations.

added to the drilling fluid during the first 500 feet of hole will usually prove to be a wise investment.

CORING: Generally speaking, cores are taken for the purpose of obtaining information regarding formation fluid content and lithology. However, getting this information depends first upon getting a decent core up to the rig floor. This is essentially a drilling problem.

Such basic information as porosity and permeability, formation hardness, size and sorting of grains in sandstones, and formation fluid content not only enable better electric log interpretation, but are vital to accurate evaluation work.

As a matter of fact, laboratory data of the physical characteristics of a sand core, when used together with the electric log picture of the same formation, may lead to the discovery of an oil sand that would have been overlooked had the formation's oil possibilities been determined only from the appearance of the core.

The estimation of fluid content from core appearance on the rig floor will depend upon numerous factors. In general, these are·

1. Nature of the oil—color, gravity, gas or gasoline content, type of base, etc.
2. Depth of hole and bottom hole pressure at the level of the formation being cored.
3. Original formation gas/oil ratio.
4. Physical characteristics of the formation.
5. Quality of the mud used while coring.
6. Position of the well on structure (When known!).
7. Time elapsed between time the core is brought to surface and time it is examined by geologist or laboratory. (Do not wash a core before it is examined for oil and/or gas. If possible, should geologist be absent, do not even take it out of the barrel until someone qualified to examine it is present.)

In addition to being on the floor when the core is taken from the core barrel, the watcher should observe the drilling action during coring. While good core recoveries should run to 75 percent or better, most recoveries will not be this good. Providing the rate of feed is kept as uniform as possible, observation of the action of the "string" while coring may provide information about the nature of the formation that can be gained in no other way.

Furthermore, for each core taken, a record showing drilling time per foot and a brief report indicating the manner in which that foot drilled should be kept. This will do much, when combined with the geologist's detailed lithologic description and estimate of fluid content, to increase the accuracy of the information.

Core recoveries can be increased, when using a conventional core barrel, by figuring the pipe so as to avoid having to make a connection while the core is being cut. This is recommended even though it may mean coring a few feet less. Although it is possible to make a connection during coring, it is a risky proposition and often results in the loss of most, or all, the core.

The well sitter should bear in mind that there is absolutely no positive consistent relationship between the appearance of a drilling sample, or circulating sample, or even a core sample, and the potential production possibilities of the formation from which it came. For this reason, when wildcatting, any sample that has an odor or taste, no matter how slight or spotty the stain, should be tested.

DRILL STEM TESTING: Since the appearance of an oil sand is often deceptive, the invention of the drill stem tester was a great boon to well-watchers, even though, in many cases, when testing low-pressure sands the chief value of the test is negative. That is to say, if the test doesn't show salt water the sand may make a small producer in spite of no oil in the drill stem.

In such cases, of course, correlative information from samples, cores, and the electric log are essential in determining whether or not to set pipe.

However, there are a few things that can be done to make a drill-stem test more effective. In the first place, as with coring and electric logging, mud and hole condition are of extreme importance. It has been shown that fully 50 percent of drill test failures are due to poor hole or mud condition.

Furthermore, even though the mud is good enough to keep the hole in shape for packer passage, it may still be so poor that its effect on the formation can ruin a test. This is especially true of low-pressure sands. Should the mud water loss be high it may block off such sands, and the test will recover only a few feet of drilling mud.

Care in picking packer seats is of particular importance and, in the absence of an electric log, can be done with consistent efficiency only when one foot drilling time and good samples are available. It is usually advisable to set the packer a foot or two into the formation to be tested and to remember, while drilling, that a short anchor below a packer will usually give better results than a long one. In addition to the difficulties of preventing "corkscrewing" pipe and packer failures with long anchors, the fluid below the packer acts as a load on the sand. This may be sufficient to ruin a test.

Always allow enough time for the

■ CONTINUED ON PAGE 106

About the Author

C. A. CASWELL received a B. S. degree in geology from the University of Oklahoma in 1940. Shortly after graduation, he went on active duty with the U. S. Army as a second lieutenant. Before being released to inactive duty as a Major in 1946, he had had 19 months of combat duty in the European theater. After his release from active duty, Caswell returned to Oklahoma University where he completed graduate hour requirements for an M.S. degree in geology. In May, 1946, he was employed by the Mack Oil Company of Duncan, Okla. Caswell resigned in August, 1948, to re-enter the University to work on his thesis and to work as a consulting engineer.

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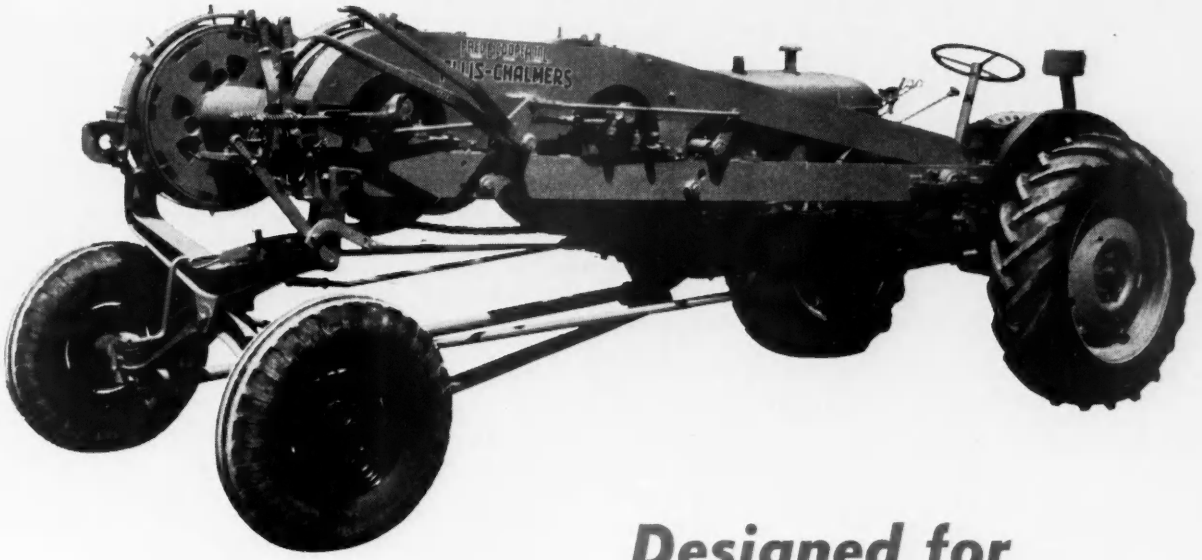

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Well Completion Practices

Part 4 (Conclusion)—Remedial Work

By DR. CARROL M. BEESON
Associate Professor of Petroleum Engineering
University of Southern California

THIS IS THE CONCLUDING instalment in the series of articles on Completion Practices. The author discusses remedial work, chiefly from the standpoint of removing plugging materials which retard the flow of oil from the drainage area into the well bore and to the surface. The discussion includes methods of remedying this type of damage to well productivity which may have occurred either during the completion operations or during the production period.

THIS instalment dealing with Remedial Work is the last of four articles on Completion Practices. Earlier articles were entitled: (1) Completions, (2) Completion Muds, and (3) Well Washing.

The term "completion" was defined in the first instalment so as to include all of the operations that occur between penetration of the producing horizon and commencement of settled production. Emphasis was placed on the need for improvement in the completion stage of drilling and producing operations. This entailed consideration of the information required for making the best choice of materials, tools and techniques, as well as means of obtaining the required information.

The second instalment dealt with completion muds, primarily to point out the factors that influence subsequent production. Because of its importance and lack of general acceptance, laboratory data were presented to support the contention that mud often is lost to formation pores. This phenomenon was differentiated from lost circulation by emphasizing the fact that mud, including solid particles, enters the pores of formations with permeabilities of a few hundred millidarcys or less.

Both aqueous and non-aqueous well washes were classified in the third article. Discussions were given of the various subtypes, for the purpose of indicating the factors that should be given consideration in choosing a wash fluid.

As the name implies, "remedial work" is performed on a well to counteract any damage done to well productivity. The damage may have been done during the completion operations, or it may have occurred during the production period. "Recompletion" is the term applied to a special type of remedial work, in which an improvement in the original completion is attempted. Whenever this is the chosen remedy, consideration should be given to all of the factors discussed in the instalment on "Completions."

Whenever an operator has reason to believe that production from a well is below normal or the cost of production is above normal, steps should be taken to remedy the situation. The same is true when either the gas-oil ratio or the water cut is too high. However, methods for the selective exclusion of water or gas will not be discussed here, as emphasis is to be placed on methods of increasing production and of decreasing the cost of production by removing plugging materials. An outline of the various types of remedies for this kind of damage is shown below.

Removing Plugging Materials

I. Filled-up (inside) liner
  A. Mechanical remedies
    1. Bailing
    2. Hydraulicking and surging
  B. Chemical remedies
    1. Reaction to disperse plugging material
    2. Reaction to dissolve plugging material

II. Plugged perforations or screens (including gravel packs)
  A. Mechanical remedies
    1. Positive displacement followed by suction
    2. Hydraulicking and surging
    3. Scratching
    4. Scraping
    5. Knifing
    6. Shooting
  B. Chemical remedies
    1. Reaction to disperse plugging material
    2. Reaction to dissolve plugging by suction

III. Plugged annulus (between liner and formation)
  A. Mechanical remedies
    1. Positive displacement with hydraulic jet, followed by suction
    2. Hydraulicking and surging
    3. Shooting
    4. Pull liner and circulate
    5. Pull liner, circulate and wall scrape
    6. Redrill
  B. Chemical remedies
    1. Reaction to disperse plugging material
    2. Reaction to dissolve plugging material

IV. Plugged formation
  A. Mechanical remedies
    1. Hydraulicking and surging
    2. Shooting
    3. Pull liner, under-ream and circulate
    4. Redrill
  B. Chemical remedies
    1. Reaction to hasten removal of water block
    2. Reaction to dissolve plugging material
    3. Reaction to dehydrate formation clays

As low production may be due to a combination of any or all of the factors outlined, all possibilities should be given consideration. Likewise, a combination of mechanical and chemical remedies should be more successful than the use of either type alone.

Vigorous mechanical action may suffice to remove material from inside a liner, or even from perforations or screens, but the result would be enhanced by auxiliary chemical action. On the other hand, removal of material from outside a liner or screen (which is to be kept in place) depends primarily on chemical action, although auxiliary mechanical action is also required.

Success in removing material from inside a liner, or cleaning plugged perforations or screens, depends both upon the chemical composition and the physical characteristics of the plugging material. An actual sample of the material always would be a help and often would

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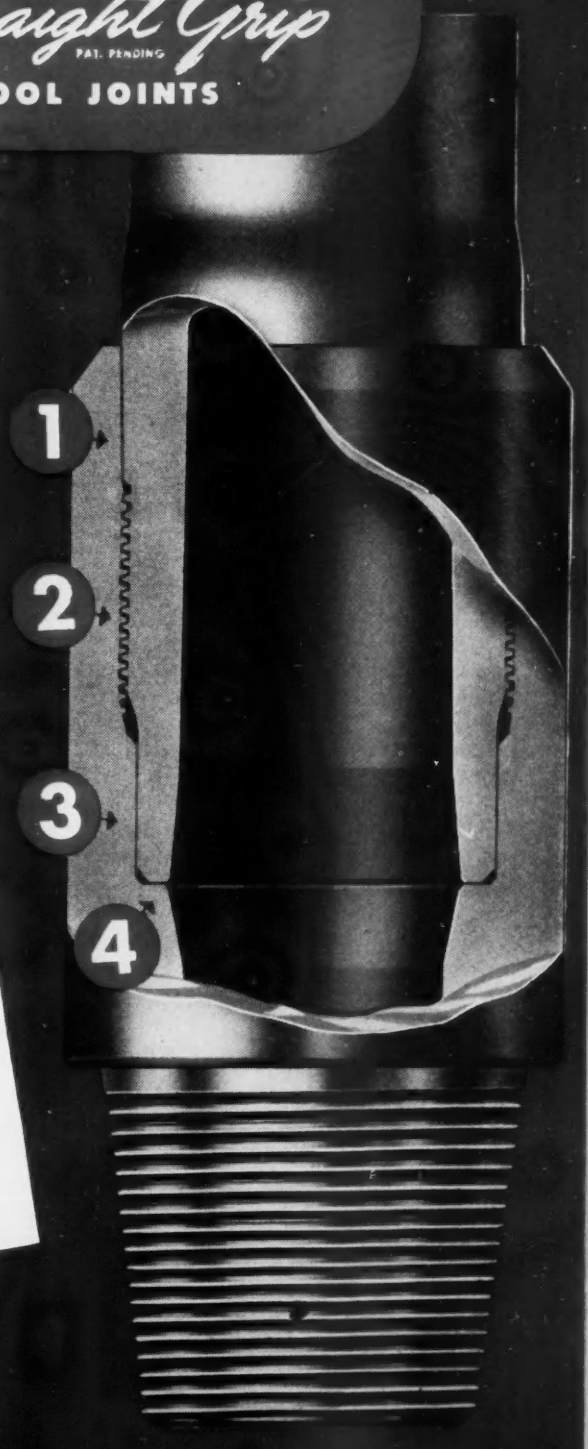

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be a necessity in achieving success in a remedial job. However, it is logical to expect improvement from a wash job which involves vigorous mechanical action of a chemical solution chosen with due consideration for the nature of the formation and the produced fluids.

In all remedial operations, definite steps should be taken to remove the plugging material as completely as possible from the well, to minimize repetition of the operations. This caution applies to the complete removal of material from behind liners and screens, even when new perforations are made.

Gelled mud, mud cake, and detritus that were not removed originally from outside the liner present a very serious problem. It is difficult enough to remove such materials from the open hole, with no liner in place. Of course, the task is considerably greater when the liner is in the way.

Success in removing plugging materials from behind liners and screens undoubtedly depends to a great extent upon the ability to obtain samples of the material for study. Laboratory tests of the samples, performed under bottom-hole conditions, should supply the information necessary for the choice of optimum wash fluids and techniques. Whenever feasible, such laboratory studies are always advisable, as the work is much less expensive than either the loss of production caused by inefficiency in washing or unnecessary repetition of the remedial work.

Cleaning plugged formations likewise must be accomplished by appropriate chemical and mechanical actions, preferably guided by laboratory work. Studies should be made of plugging agents that may have been introduced during completion operations, as well as plugging materials that may have formed during producing operations. The former include mud particles, mud filtrate, and precipitates formed with the interstitial fluids. The latter include sand, silt, carbonaceous scale, and wax or asphalt.

Another very important consideration is the removal from the face of the formation of any material which may retard or even prevent the entrance of the wash fluid into the formation. Otherwise the fluid could scarcely be expected to increase the oil permeability of the formation.

In this connection, it may prove very worth while to explore the possibility of increasing the oil permeability through base exchange of any clay particles intermingled with the sands. For example, a high sodium to calcium ratio in the filtrate from the completion mud may have base exchanged most of the calcium and magnesium clays to sodium clays. In this case, a wash containing a high proportion of a polyvalent positive ion would reverse the base exchange and at least partially remedy the loss in permeability. As usual the advantage to be anticipated from such a procedure should be tested in the laboratory, using formation samples and formation fluids.

Each of the following points should be given careful consideration in planning a remedial job. A minimum pressure should be exerted on the formation. Also it is usually less hazardous to execute the operation in a minimum of time. The fluid ordinarily is more effective when heated and when vigorous agitation is employed. An adequate volume of wash fluid should be used, taking into account the amount that may enter the formation. Elaboration of some of these considerations follow.

Wells with low formation pressures are seldom washed by fluid circulation from surface equipment. This is due to the fact that a column of fluid, even with a density as low as that of oil, may impose too much pressure on the formation. For this situation, there are excellent washing tools of the suction-pressure type which can operate in fluid with a level just sufficient for submergence throughout the travel of the operating stroke. When these tools give suitable agitation, their use permits reducing the fluid head to a minimum. In this case, however, care must be exercised to insure the presence of an adequate volume of the wash fluid for the job at hand.

Complete filling of the hole with the wash fluid permits almost any desired degree of agitation by hydraulicking and surging. The desired degree of agitation may be realized through circulation of the wash fluid, providing appropriate wash tools and the proper surface equipment are employed. It is advisable with this method, however, to give due consideration to the density of the wash fluid, as affecting the net pressure exerted on the formation.

As stated in the third instalment, success in well washing has already been demonstrated[1] on the basis of the net effect on a number of wells. It also seems appropriate in the present article to emphasize that the percentage of successful wash jobs performed either during or subsequent to completion, should rise in proportion to the amount of development work and engineering that is done. Such work, of course, should include experiments conducted in the laboratory and in the field, as well as the continued development of washing tools. The resulting improvements undoubtedly will cause both completion washing and remedial work to grow continually more important among the techniques used to increase the recovery of oil.

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[1] Cabeen, W. R., and Bemis, E. G., "Field Performance of Sand Control Liners in California," API Paper No. 801-25K, presented at the Los Angeles meeting, May 12-13, 1949.

Sitting on a Well

■ CONTINUED FROM PAGE 102

fluid to move from the formation into the pipe. Usually, the action of the "bubble hose," or flow line, will help in estimating the amount of time needed. But, as long as fluid is moving into the pipe, and the mud level at the top of the surface pipe is not dropping excessively, allow at least an hour for a good test.

As a general rule, 15 to 30 minutes will be enough shutin time to give a good determination of bottom-hole pressure. Ordinarily a high pressure formation will require less time than a low pressure formation and this can be estimated by observing the action of the test while the tool was open.

Conclusions

Since any, or all, of the means used to discover oil sands may give erroneous information, or be erroneously interpreted, the problem is always one of coordinating the information it is possible to get about any particular sand. Anything that will add to this information while drilling the well should be done.

Unfortunately, the procedures required to get this information may add to the cost of completing the hole. For this reason, many operators hesitate to take these steps. But, after all, the true comparison of cost is not between the cost of a slow hole and the cost of a fast hole; it is between the cost of completing a dry hole and completing an oil well.

If the extra day or two of drilling time that is lost by using proper mud, by circulating drilling breaks, by close watching, by coring, and by testing, results in the discovery of an oil well, then it can hardly be said that these requirements add disproportionately to the cost of drilling the well.

These "requirements" are not put upon us by the geologist; they are forced upon us by the nature of the physical conditions of the occurrence of oil and the imperfections inherent in the means we have of discovering its presence.

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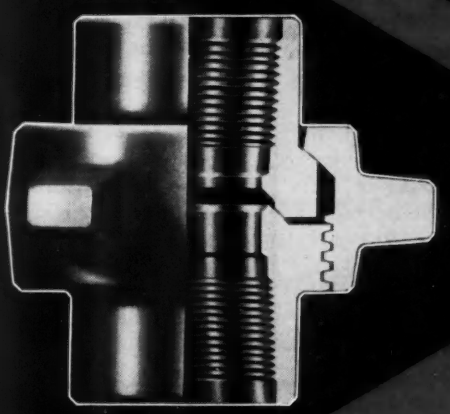

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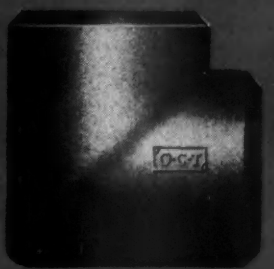

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A Model Design of a *New Type Drilling Barge*

By FRANK BRIGGS

FIGURE 1. The model of the deep water drilling barge was built to 1/40 of the actual size rig. The structure as shown in this photograph is in drilling position.

SEARCH FOR the solution to the offshore drilling platform continues. In this article the writer describes a novel type of barge-platform with hinged sides which are designed to increase the foundation during drilling and reduce the scour of currents under the central bearing area. Shown in model form, the design offers another approach to the basic problem of derrick support.

WITH the offshore tidelands drilling situation considerably muddled over the question of national or state ownership, and with drilling budgets still fluid and fluctuating with the political question marks involving petroleum, introduction of a more economical drilling platform for deep offshore operations may be the factor that will tend to determine many of the larger drilling programs.

In some shallow locations, and all deep water sites, the use of piers as drilling platforms is necessary. These structures alone represents sums exceeding $1 million, each of which, together with the other costs for equipment and auxiliary floating units, adds up to a prohibitive investment for drilling on small acreage. Following the usual government procedure, it is believed that under national supervision only small unit blocks would be permitted the operator, thus making the multi-million dollar tidelands venture most uneconomical. It is possible that with a removable (by floating) structure, economical in that it can be used over and over again with each new location, the offshore development may proceed even under restrictive measures.

One such drilling possibility has been developed as a model barge with dimensions and strength capable of drilling (with the actual rig) in sea depths up to 40 or 45 feet. This strange appearing craft has the foundation requirements for drilling and stability in motion while being towed from location to location. In depths of 40 feet, it presents only the area of its uprights against the seas; the drilling platform is still 28 feet above the normal sea level. Washouts, due to underwater currents, of the sea floor supporting the barge are practically impossible; no costly salvage operations to remove hazards to navigation upon completion of wells are involved.

Description of Model

The model has the basic appearance of the usual drilling barge; from a plan view, it is rectangular in shape, prismoidal from a volumetric standpoint. The floating assembly is the usual scow or barge; this forms the foundation for the substructure supporting the platform and the derrick. The unit derives its turtle-like appearance from side boards, hinged at the bottom of the barge, and placed on all four sides. In transit, these are raised; in operation, these boards carry pontoons for greater stability in setting the rig on bottom; and when this is accomplished, they act as an addition to the foundation for the greater distribution of the drilling load.

Beginning from the topside, the unit is crowned with the usual derrick structure, except for the variation in mounting. To facilitate the sea-going ability of the barge, the derrick is hinged on two legs and is designed to be laid down

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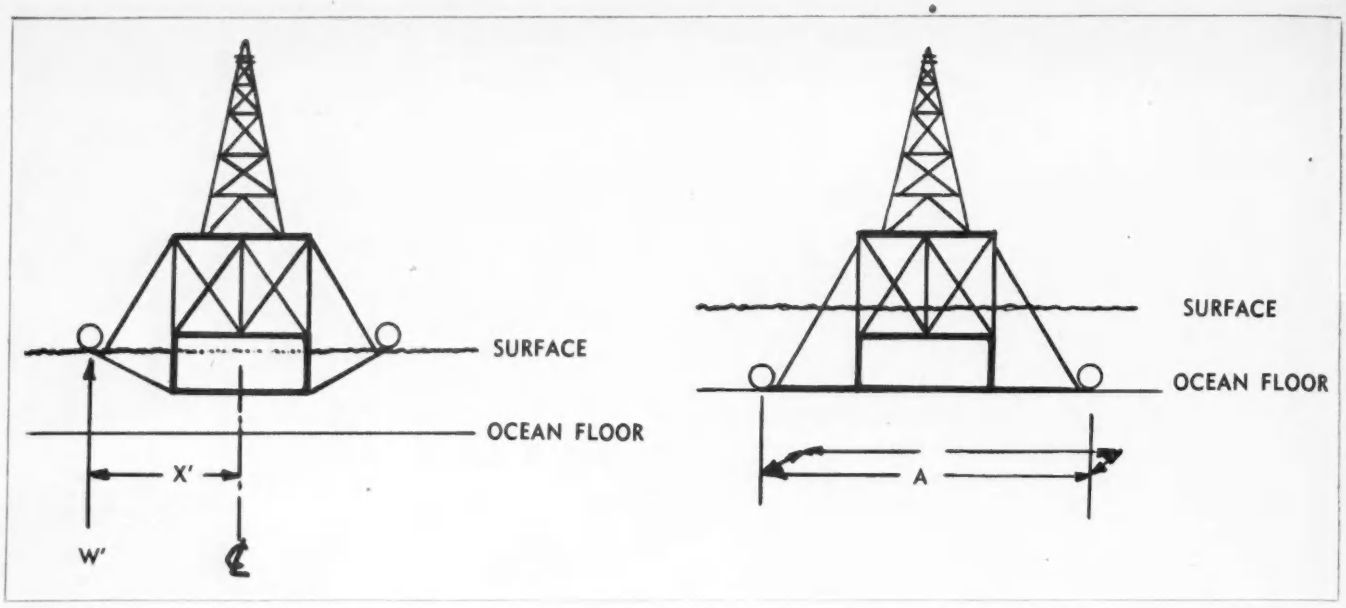

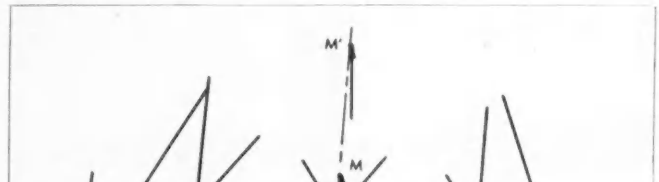

FIGURE 2 (left). This schematic diagram is used in calculating the metacentric height. The point M is the metacenter without pontoons, and M' the metacenter with pontoons added.

FIGURE 3 (above). These sketches show the rig settling on location and finally in drilling position. The pontoons afford a righting moment of about 55 million foot-pounds; the side boards increase the base area to more than five times that of a conventional rig of the same dimensions.

across the deck when not in use or in transit. The substructure is a welded unit of columns and cross-members fabricated in the conventional bridge type form. The barge, completely enclosed, is of the usual slotted-end design. As previously described, side boards are hinged from the bottom of the vessel on all four sides; those on the front are split to conform with the passage for the well-head. Jet nozzles project above and below the hinge line of the boards; from these high velocity water streams are shot to break the suction of the ocean floor and to wash the effluent sand from the confines of the side members.

Side Boards

The side boards are the unique feature of this assembly; they are the means, in conjunction with the pontoons, of providing stability to the vessel while sinking it over a well site. When drilling, the side boards rest on the ocean floor and provides the additional foundation to carry the drilling loads. A rachet-type stiff-arm, expansible or contractible, as desired, connects to the boards just below the point where the pontoons are attached and transmits the side thrust from these members to the substructure when the rachet is released, the arms telescope within themselves. Cables and winches raise and lower these side members.

The model dimensions, as shown in Figure 1, approximate 1/40 of the proposed size of the actual rig. From bow to stern, the barge model measures 26 inches; it has a beam of 16 inches. From bottom to the top of the platform, the 20½-inch measurement includes 8 inches of barge height and 12½ inches of substructure. All side board members are 17½ inches from the hinge to the outer edge; the pontoons, which incidentally are carried on the long members only, are four inches in diameter and are the length of the barge. Like the barge, the pontoons are to be water filled when the rig is drilling; the water is to be expelled when it is desired to refloat the unit. The base area of the model is 416 square inches; with the side boards expanded on bottom, this base area is increased by 1690 square inches to a total foundation of 2106 square inches. This figure is more than five times greater than the foundation area of the conventional barge of the same dimensions. The buoyancy of the pontoons provides a righting moment of approximately 22.6 foot-pounds; the area of the substructure members exposed to wave action amounts to less than 9 inches diametrically.

Actual Size Barge

Approximately 40 times larger than the model, the actual drilling barge would measure 90 feet long, 54 feet wide, and 25 feet high. The substructure would rise 40 feet above this to a total height of 65 feet from bottom. Using these dimensions and assuming certain other values, the calculations of stability and foundation are of concern.

Consider Figure 2. In the hull whose dimensions are listed above, the center of gravity G is in the line of symmetry and reposes two feet above the water

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line; the vessel draws 15 feet of water. Assume a momentary angle of heel (tilt) of 10 degrees occurs. The metacentric height (which is a measure of the stability of a vessel) is represented by the distance GM and may be found as follows:

From triangle A'C'K, distance C'K equals 54 tan 10° or 9.5'. Distance KF equals 15 — 9.5/2 or 10.2'. To find BL, take moments about side HF.

$(15 \times 54)BL = (10.2 \times 54 \times 10.2/2) + (9.5/2 \times 54) \times (10.2 + 9.5/3)$

$BL = 6256.3/810$ or 7.7'

To find BN, take moments about side EF.

$(15 \times 54)BN = (10.2 \times 54 \times 54/2) + (9.5/2 \times 54 \times 54/3)$

$BN = 19537.2/810$ or 24.1'

Distance BB' equals 54/2 — 24.1 or 2.9'

From similar triangles,

$MB'/BB' = A'K/C'K$

$MB' = 2.9 \times 54/9.5$ or 16.5'

Metacentric height, GM, equals MB' + B'L — GL

$GM = 16.5 + 7.7 - 17$ or 7.2'

The righting moment equals the buoyant force times the length of the arm at which this force acts; the buoyant force W is equivalent to the weight of the water displaced. If X represents the distance between the forces acting at G and at M, the righting moment is WX.

$WX = 90 \times 54 \times 15 \times 62.4 \times 7.2 \sin 10°$ or 5,457,700 foot-pounds. The weight of fresh water is 62.4 pounds per cubic foot; sea-water approximately 64 pounds per cubic foot.

The above calculations were made without considering the effect of the pontoons upon the values obtained. To show the tremendous stabilizing action of the pontoons, consider the righting moment derived from the same initial barge conditions. This moment due to the pontoons alone may be expressed

$W'X' = (3.14 \times 6.5^2 \times 90) \times 62.4 \times 75$ or 55,177,500 foot-pounds. The combined righting moment of the barge and pontoons is 60,635,200 foot-pounds. To show the increased metacentric height,

$GM' = 60,635,200/4,548,960 \times .173$ or 77.2'

Base Area Comparison

To compare the greater base area of the barge equipped with side boards to that of the conventional barge of the same dimensions, 90×54 feet provides an area of 4860 square feet. Each of the lengthwise boards, being 90×60 feet, adds 5400 square feet and each of the end boards contributes 3240 square feet, making an additional area of 17,280 square feet. The total base area for drilling load distribution is 22,140 square feet, or about 5½ times the conventional base area. In operation, the pontoons ride the surface of the sea and as the barge settles to the drilling location, the telescoping stiff arms automatically conform to the proper length to transmit the stabilizing effect of the float to the substructure. After completion of the stabilizing duties, the pontoons are flooded and the side board assembly then sinks to bottom. Each member is in a horizontal position acting as the enlarged base for drilling load distribution.

In rough seas, the substructure presents but small area to the wave force. Assume waves of 20 feet from crest to root, the total area presented by the columns and cross members of the pier approximates only 600 square feet. This figure is based on the same 1-in-40 proportion carried throughout all dimensions.

Upon completion of the well, jets break the suction of the ocean floor and wash the sand from the side boards. The pontoons are refloated; the water expelled from the barge. Cables draw the side boards to a vertical position, the derrick is lowered and the rig is then seaworthy. As an alternative, the pontoons may be detached from the boards when they are to be used as the foundation; they may be raised and lowered by wire lines alone. Such detachment would eliminate pumps and hose for the sinking and refloating of the pontoons.

FIGURE 4 (left). The great stability of the barge with pontoons in place can be visualized from this photograph of the model.

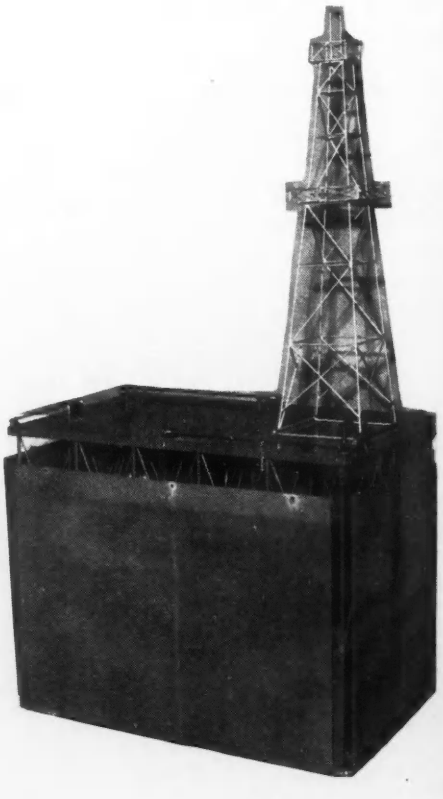

FIGURE 5 (right). With side boards folded up, the barge is sea-worthy and ready to move to the next location.

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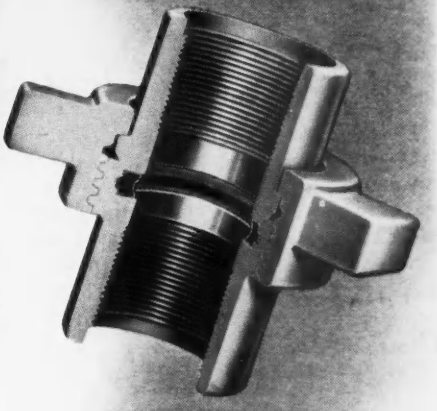

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HOW TO—Manifold Boiler Blowdown Lines

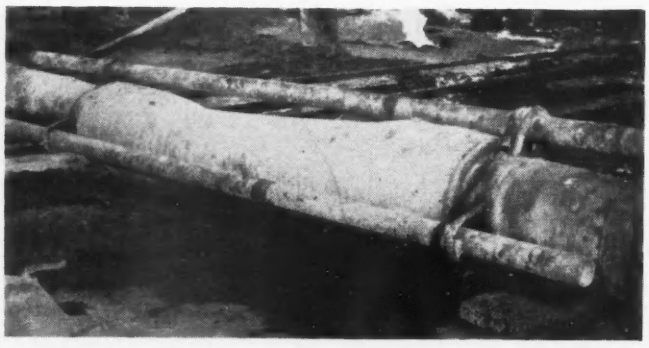
Savings in piping and installation time can be effected by manifolding the blowdown lines of each boiler into a larger, single section of exhaust pipe. Instead of laying a small line extending from each boiler to a point 60 or 70 feet from the stack, the steam blowdown line can join a large header which extends across the entire boiler battery as shown. This header preferably of six-inch pipe, is then flanged to an extension line which discharges the steam a safe distance from the boilers and rig.

The blowdown line, usually about two inches in diameter, is brought out of the battery below the stack and header. It is firmly anchored and a union coupling is added. An extension of the small line is made with a long right-angle bend as shown, terminating at another union coupling which attaches to a short nipple welded at an angle to the large steam header.

While the battery illustrated serves two rigs, the principle can apply with equal advantage to three- or four-boiler batteries. Since it is not frequent that more than one or possibly two boilers are blown down at one time, the line is of ample capacity.

Each battery of four boilers shown is held and supported at the stack end by a unitized skid tie-down. Each boiler is held to the unitized skid by two turnbuckles which can be tightened or unbolted easily. Each boiler saddle is supported on the fabricated tie-down skid which consists of longitudinal pipe runners reinforced by I-beam cross pieces. Automatic spacing is achieved by this skid and a foundation for the boilers is provided.

HOW TO—Safeguard Mud Pump Suction Hose



Moving heavy flexible hose from one location to another is to incur more damage than in normal operating service. This is true in many cases for rotary hose, and may also be said about the large flexible suction hose on mud pumps. This hose has become standard equipment on drilling rigs as a means of adjusting the suction level to conform to level of mud in the pit.

To obtain maximum service from such pump suction hoses, a protective guard can be added which will prevent crimping or flattening the hose by loading other material on top of it. Illustrated is one means of adding this protection. Three pieces of two-inch pipe completely span the flexible hose and extend for about two feet over the casing inserted into either end of the hose. Sucker rod "U" pieces have been welded to each end of the casing as shown on 120-degree arc spacing. Radius of the rod bend exactly fitted the outside of the two-inch pipe, and the two were welded together to form a coupling that would flex slightly, but was strong enough to protect the hose.

In tearing down the rig for a move, the entire suction line was loaded as a unit instead of breaking the hose from the longer section of casing. Extensions of the two-inch pieces provide handles with which two men can lift the suction line when coupling it to the pump.

HOW TO—Detect Pin-Hole Leaks in Drill Pipe

Drill pipe and tool joint failures have been the subject of intensive investigation during the past eight or ten years. As drilling depths continue deeper and deeper, drill pipe becomes a critical item and an expensive one. The origin of drill pipe failures varies from slip marks to corrosion fatigue. Much progress has been made in the care of drill pipe to reduce such failures, but drilling reports continue to show twist-offs, parted drill stem, etc. In these cases, the most expensive part of the failure is the fishing job which results. If the hole is relatively deep and wall conditions are critical, the fish may be extremely difficult to recover, if recovered at all. In many instances, drill pipe failures have brought on a sidetracking job.

Here is a practical idea that will aid the drilling crews to detect the beginning of a drill pipe failure. This method has been in use in the West Texas area where drill pipe service is severe, and on many occasions has eliminated a drill pipe failure by indicating a pin-hole leak before the pipe had a chance to part or be cut out by drilling fluid.

The idea involves a "muletail" or large handful of manila strands cut from discarded catline. The muletail is placed inside the drill pipe prior to pulling the pipe from the hole. This can be done when adding the last joint to drill 20 or 30 more feet before coming out of the hole, or it can be added by breaking the kelly joint. Enough time is allowed for the muletail to be pumped to the bottom of the drill stem before coming out of the hole. As each stand is pulled and racked on the floor, it is carefully examined by both the derrickman and the pipe racker. Small pin hole leaks will be indicated by strands of manila piercing the hole as shown in the inset. Pump pressure causes the fine hair-like strands to enter the small holes. A few strands will become lodged and may be detected once the pipe is racked in the derrick. In areas where drill pipe failures are eminent, use of the muletail idea can prove a "fishing" time saver.

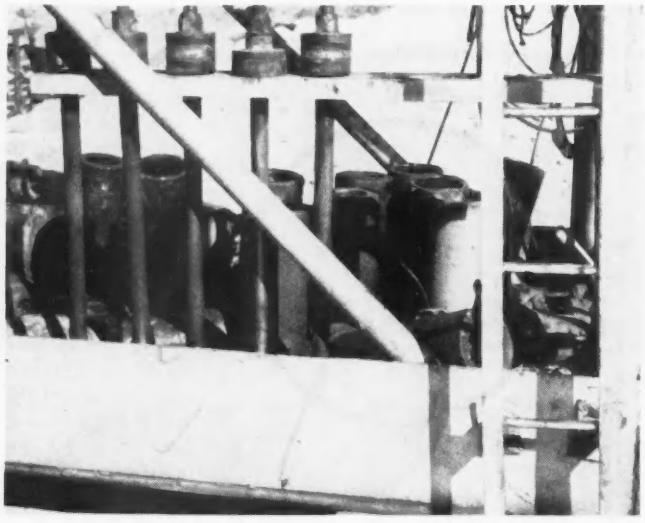
HOW TO—Install Lubricating Device on Mud Pump

The advantages of lubricating mud pump piston rods with oil rather than with a constant flow of water have long been acknowledged. Here is a simplified lubricating system that can be installed on the mud pump without much difficulty.

The system provides for a continuous flow of oil over the piston rods while the pump is operating. A small gear type oil pump is mounted on the skid foundation and is driven by a V-belt looped over the extension of the pump crank shaft. The exposed crank shaft, V-belt and pulley are fully protected as a maintenance and safety measure. The V-belt cover is made of a split section of two-inch pipe welded to sheet steel and supported at both the crank and pump ends.

The positive gear-type pump discharges lubricating oil into a storage reservoir of 6⅝-inch casing mounted on top of the pump between the two cylinders. Flow of oil is directed through small copper tubing to the piston rods. Oil drips off the rods and flows into the oil sump. This sump was made of a 3½-foot section of three-inch pipe attached to the pump by a short nipple and an ell. Neoprene rubber hose connects both the pump intake and discharge, thereby eliminating many pipe fittings. The oil sump contains sufficient oil that the level is above the intake of the small gear pump, thereby insuring constant delivery into the oil reservoir.

HOW TO—Build Pump Piston Rack



Water storage tanks in a West Texas drilling rig created additional parts storage space. The large water tank was mounted on an elevated platform, the lower section of which was skid mounted. The tank itself provided protection from sun and rain, so the lower section was floored over with plate steel and a 14-inch enclosure was welded to the sides. In this area were stored many miscellaneous parts required on the rig.

A special rack was included for the storage of worn and unused mud pump pistons and rods. It was a six-foot section of four-inch channel iron welded to one of the corner legs of the tank platform and supported near its outer end by angular pipe braces which provide rigidity to the platform. Holes were cut in the horizontal channel to accept the piston rods. The piston prevents the rod from falling through the rack. In this storage rack, the pistons are readily available when needed, and are protected to a large extent by the tank overhead.

HOW TO—Affix Rig Tie-Down Post

A steel cable high-line strung from a convenient point on the derrick to a tie-down post attached to the end of the catwalk is a labor-saving as well as a time saving development when it is time to lay down the drill pipe. It is also useful in conveying objects, too heavy to carry by hand, from the catwalk to the derrick floor.

The steel high-line cable supports a trolley which acts as a lift for one end of the drill pipe while the other end is handled by the catline. This labor-saver has long been in use in the drilling industry and many innovations have been incorporated in the basic idea.

Here is a simplified method of attaching the high-line or tie-down post to the far end of the catwalk. In this case, the heavy post is made of salvaged 3½-inch drill pipe with one end equipped with a box. The upper end of the high-line post extends about five feet above the catwalk level.

The pin end of a discarded joint of drill pipe was cut off at the upset and used as the anchor for the high-line post. Since the catwalk was made of three-inch pipe and made to form its own skid, the pin section was attached to the lower cross piece as shown. A ring about two inches wide was cut from a piece of six-inch casing and welded to the three-inch cross member and to the tool joint pin as shown. The high-line post can be easily removed by unscrewing it from this tool joint pin anchored to the catwalk structure.

HOW TO—Store Crew Clothing In Metal Lockers

Three large steel lockers have been constructed in the combination change room and rig office. These lockers provide ample storage space for the crew's work clothes when they are off duty and for their street clothing during working hours.

Commonly used are hooks and hangers along the side walls of these change houses, but keeping the crew's clothing in such places invites borrowing hard hats, gloves, etc., or even pilfering by unauthorized visitors on the rig. Placing the crew's clothing in closed metal lockers eliminated much of the trouble.

Three metal lockers were installed in one corner of the change house as shown. Each locker was equipped with a hasp, although no lock was used. They were labelled according to the three tours working on the rig, that is, "Morning Tour," "Day Tour" and Evening Tour." In these lockers, the men hung their work clothing when leaving the rig, and also kept their street clothing when working on the rig.

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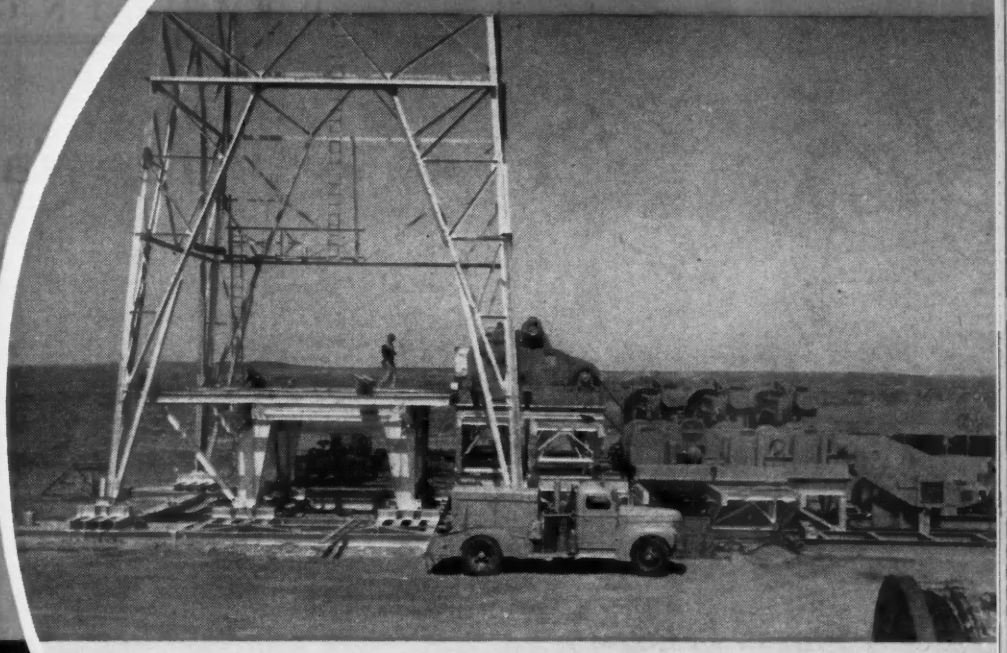
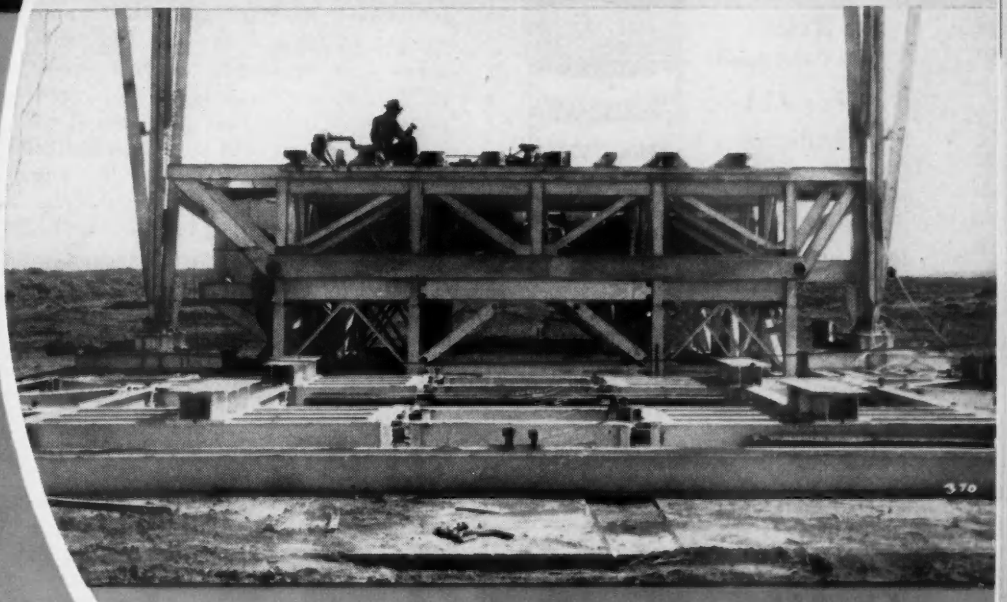


Above shows modern Lee C. Moore substructures for derrick floor, drawworks and power unit. The derrick substructure posts are positioned to take, most efficiently, the rotary and set back loads with minimum span of beam members, therefore maximum headroom is obtained for given floor height. Please note derrick substructure is independent of derrick and drawworks support is independent of derrick substructure.

Picture to right shows unitized pin connected grillage which accomplished proper distribution of loads on reinforced concrete mat. Picture taken before installation of derrick sub-structure. Also shown is well end of drawworks support. Note welded benches sized for transportation and provided with heavy pin connections for fast assembly.



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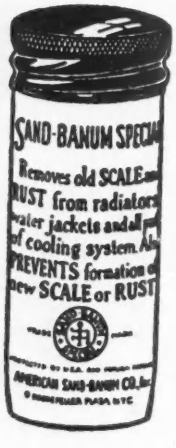

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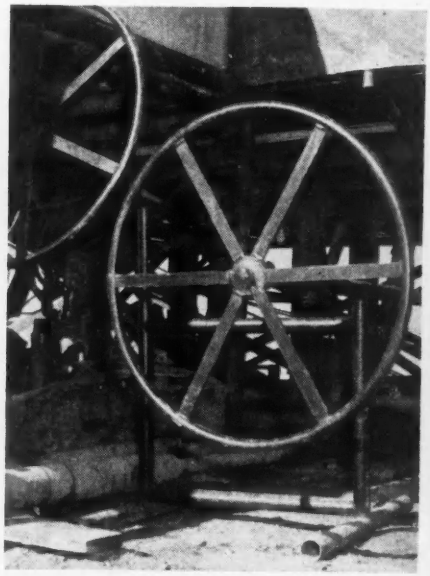
HOW TO—Unitize Valve Extensions

In addition to hydraulic means of closing the blowout preventers, mechanical methods are still utilized as a safety measure in case the pressure lines to the preventers fail. Illustrated is a commonly used method of extending the valve stems on the preventers to a point outside the derrick floor where both the upper and the lower valves can be closed from one side of the derrick. Normal practice has been to support these valve stem extensions separately, and in some cases by an unstable rest.

By incorporating both extensions on one support, not only was the rest stabilized, but the relative positions of both valve wheels were held fixed. Three-inch and 2½-inch pipe was used in constructing the support. The larger-sized pipes formed the foundation pieces and were about four feet long. Vertical legs extending to the lower valve stem extension were also of three-inch pipe. The elevated support of the higher valve wheel stem was made of 2½-inch pipe which telescoped inside the three-inch leg at the far left. This made it simple to adjust the height of the wheel.

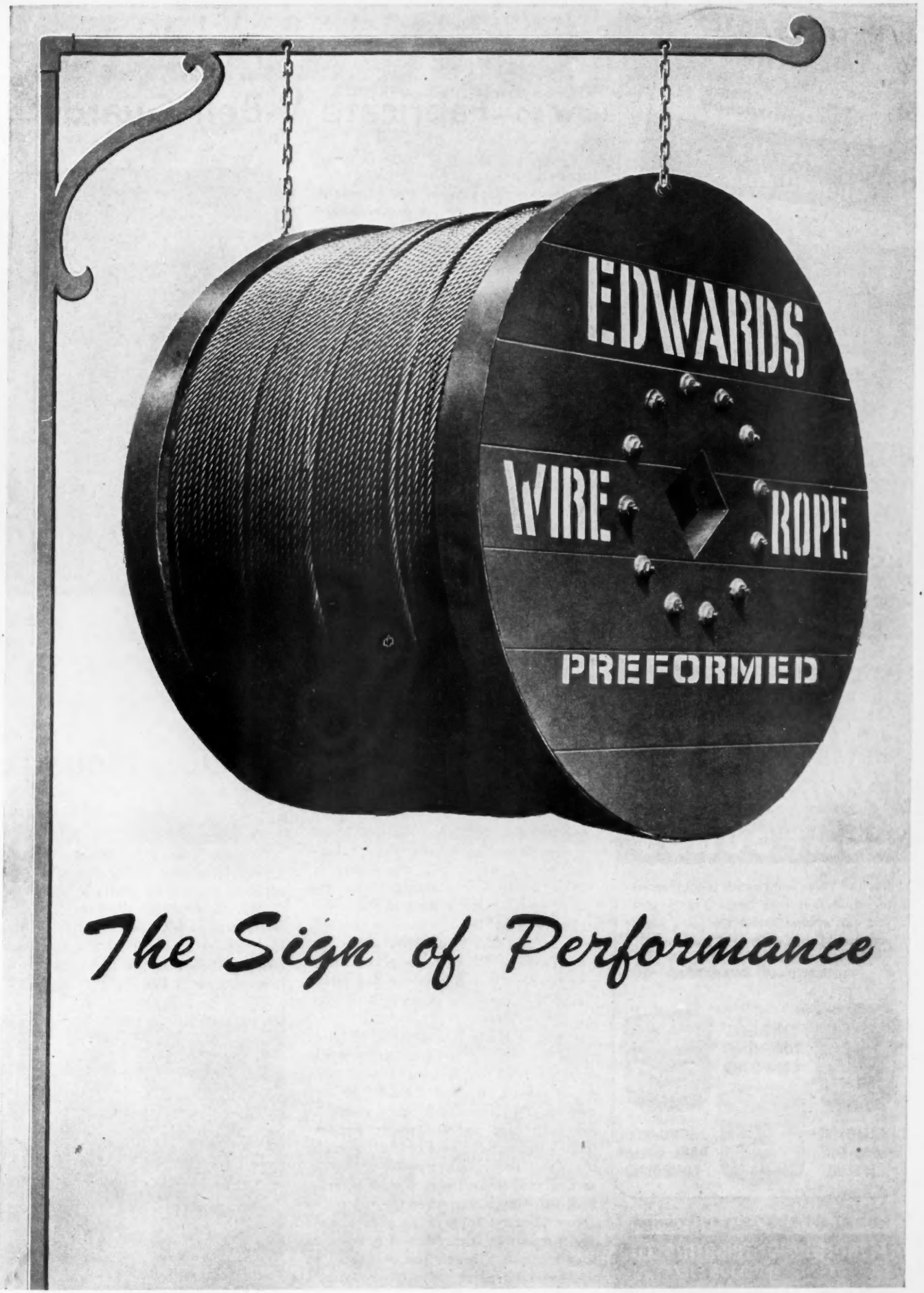


HOW TO—Reduce Drill Pipe Failures

Investigations into cause and prevention of drill pipe and tool joint failures revealed that slip marks and other tool marks were responsible in many cases for the complete failure of drill pipe. These small indentations are caused by dropping a heavy drill stem load on the slips so that the teeth of the slips bite into the metal surface of the drill pipe near the tool joint. Similar cuts or indentations are made by tool joint threading machines.

These ruptures or marks on the surface of the drill pipe result in a concentration of stress at the indentation. Corrosion fatigue is particularly damaging and also intensifies its attack on these weakened points. Research has proved that metal in a state of stress is most easily atacked by corrosion. Slip marks indent the pipe at the surface, but the effects of the cut can be found to go deeper than the cut itself.

Much of the damage which results from slip marks and pipe machine indentation can be reduced and eliminated, if not too deep, by smoothing off the pipe surface to distribute the stress and strain. A simple and effective method of removing slip marks is by filing with a fine-tooth metal file. When drill pipe is noted to have slip marks, it can be set aside and marked with paint so other crews may know why it was rejected. Once the surface is smoothed out by filing, the joint can be placed back in service. Preventive maintenance on drill pipe in this manner will pay rich rewards in reducing costly failures.



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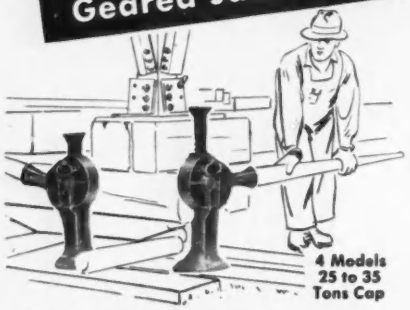

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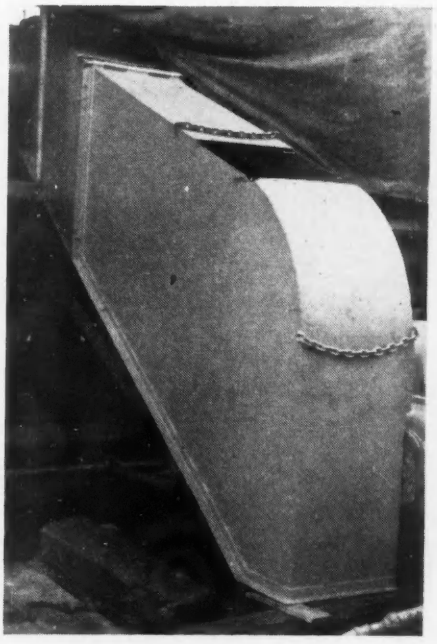
HOW TO—Fabricate V-Belt Guard

Chain guards on drawworks-driven rotaries as well as metal guards placed over V-belt drives on mud pumps are bulky and flimsy pieces of equipment to handle when moving the rig. By making such V-belt guards in two sections, their assembly and moving are greatly facilitated.

Illustrated is one method of accomplishing this division. The V-belt guard is made of sheet steel, reinforced on the edges with angle iron. It is made in two pieces which can be hinged together as shown. Angle iron welded around the edges of the cut form flanges through which bolts can be inserted to make the guard rigid.

The upper edge of this division incorporates a hinge which makes it possible to lift either end of the guard in replacing V-belts without removing the complete guard. The hinge is locked by a piece of steel rod, one end of which is bent at right angles to form a pulling handle. The hinge may be unjoined by pulling this rod from the interlocking parts.

Short links of chain were welded across the width of the guard to lift it. A winch truck can be tied on to these chain sections to load the guard on the truck bed.

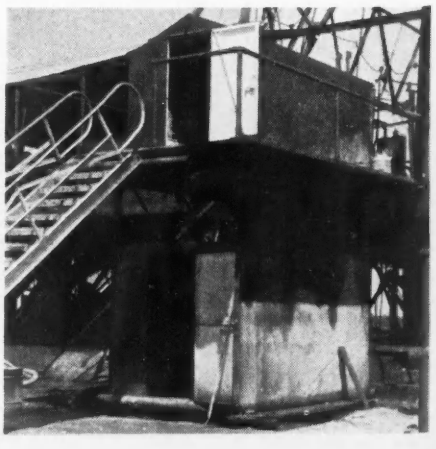


HOW TO—Unitize Tool, Dog House

Considerable moving time and space were saved by unitizing the tool house and dog house as shown. For convenience to the crew, the dog house or change house was elevated above the tool house so that the floor of the upper structure was level with the derrick floor. Metal stairway attached to the upper framework and supported run-arounds on either side of the dog house served as a means of going to and from the derrick floor.

The tool house, constructed of sheet metal on angle-iron steel framework, was mounted on a conventional skid which served as a foundation. The corners of the framework were made of four-inch pipe and the upper end extended through the roof of the lower unit for about six inches. Inside these four-inch corner posts were inserted three-inch legs which supported the top structure. Matching holes in the corner posts and supporting legs made it possible to insert a bolt through the two pipes to make a telescoping, adjustable platform on top. The dog house could be supported at any desired level and adjusted to the derrick floor height.

The dog house, mounted separately on a skid, fitted into a slot made into the upper supporting platform which included the folding walkways. The dog house was pulled onto the derrick floor for transfer to trucks, while the lower unit was handled by a winch line to lift it upon a truck bed.



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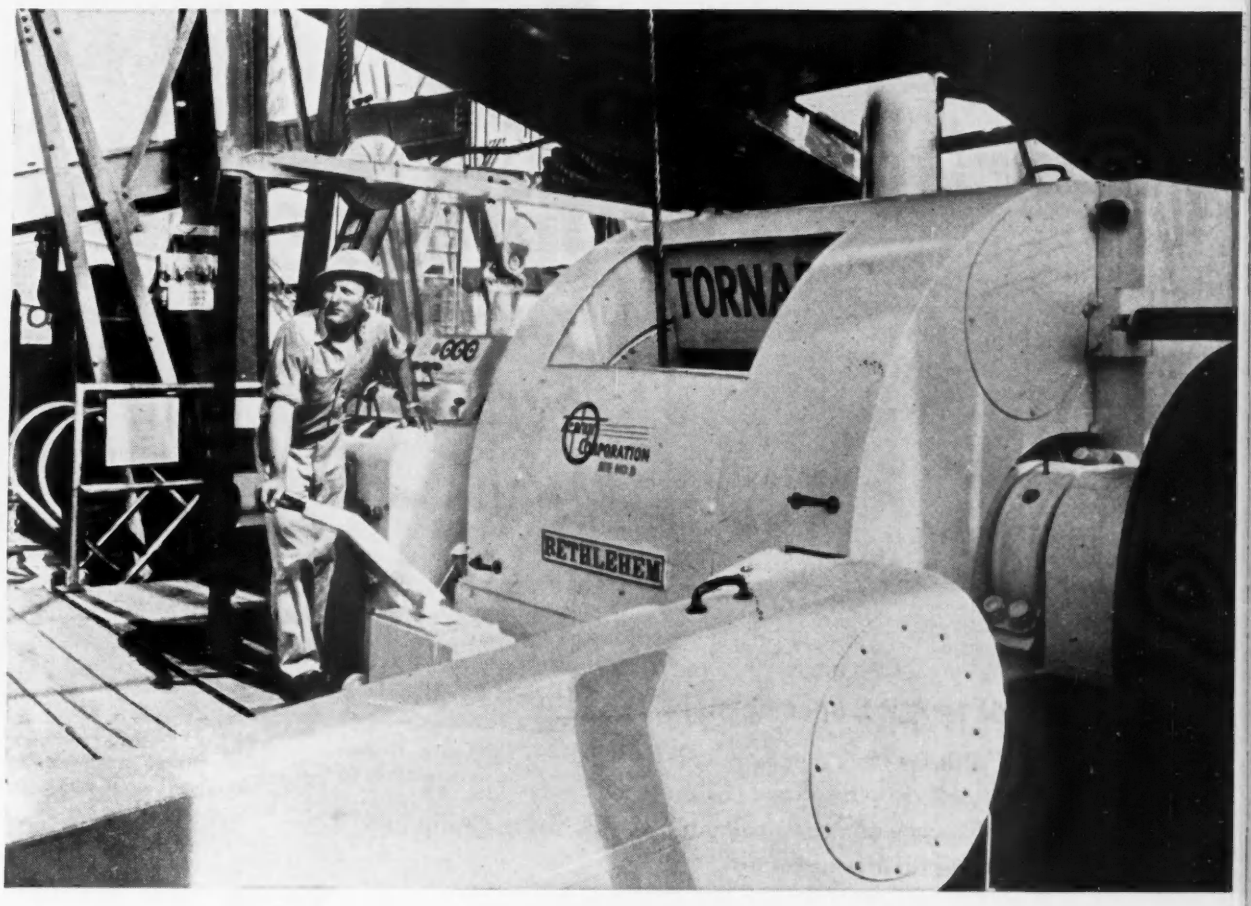

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HOW TO—Make Cover for Surveying Instruments

Unless special care is taken to store protect well surveying instruments, damage or loss may result. Standard procedure of running a sure shot at intervals during the drilling of a well makes it necessary that the instruments be available at all times. Keeping such an instrument in a safe place where it can always be found has been the problem of many drillers. Much time is saved in running the sure shot and accuracy of the survey is insured if the instrument is well protected between runs and is ready for use at all times.

To meet these needs is a handy container made of two-inch pipe. Length of the container may vary according to the height desired. In the case illustrated, the container was made of two pieces of two-inch pipe which joined together measured about three feet. The lower piece of two-inch, about 14 inches long, was blanked off prior to welding to the upper piece, so that when the surveying instrument was inserted into the container, part of it was exposed.

A flange was welded to the foot of the container and the unit was bolted to the derrick floor out of the way of machinery and tools. About six inches below the upper end of the two-inch pipe, a short nipple of 2½-inch pipe was tack-welded. This nipple serves as a stop for the 2½-inch cover which is placed over the container and the surveying instrument. This cover is about 18 inches long and is orange-peeled at the upper end. When covered, the container affords adequate protection for the sure shot and its location makes it ready for use at all times.

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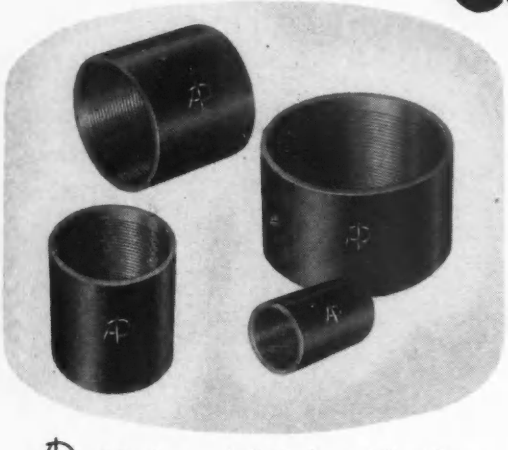

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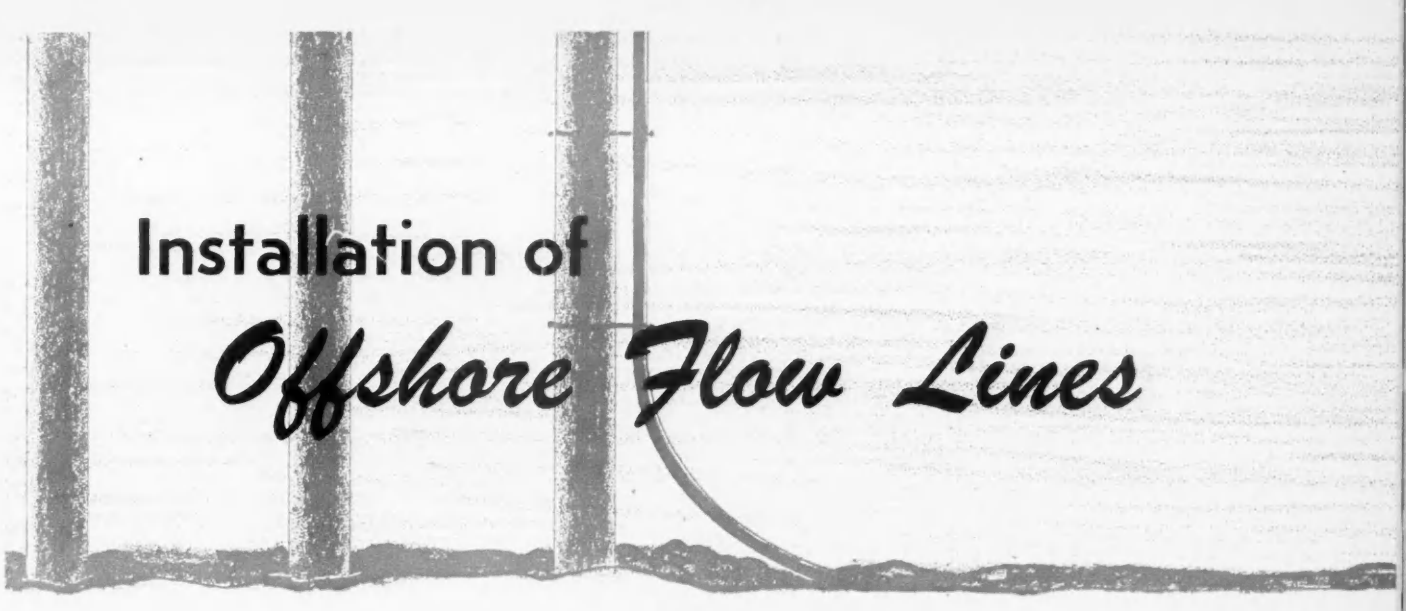


Installation of Offshore Flow Lines

By

H. E. DENZLER JR., JOHN W. SCOTT AND JAMES M. WEST
The California Company, Gulf Coast Division

PROBLEMS ENCOUNTERED in tying offshore production to shore facilities are described by the authors, who outline probable difficulties which must be overcome if Continental Shelf production is to be made available under all types of weather and current conditions in the Gulf. The paper, substantially as here presented, was read before the Petroleum Branch, AIME, in San Antonio.

OFFSHORE drilling in the Gulf of Mexico has presented a number of unfamiliar problems. Drilling and producing equipment and materials have been well standardized but the foundations, supply of rigs, transfer of personnel, and handling of production have been matters about which little was known until very recently. Considerable experience has been gained and much progress has been made, but these problems are still far from a satisfactory or economical solution. Naturally, the handling of production was the last problem encountered due to the necessity of first obtaining it.

The California Company obtained production in two areas off the Louisiana coast, one known as Bay Marchand field and the other Main Pass field. It became evident from the progress of drilling that this production would be extensive, not only in the area covered, but also in the volume to be handled.

Numerous studies, plans and estimates were made on the disposition of the crude—none of which appeared to be as satisfactory or economical as desired. In general, these studies indicated that there were four methods of solution to the problem:

1. Install all the necessary tankage, separation, treating, living and loading facilities in the Gulf on a production platform adjacent to the drilling structure and pick up the oil periodically by a barge or small tanker.

2. Install as few facilities as possible on a structure, flow from the separator into a small tank and then into a barge moored alongside.

3. Flow the wells ashore and have all the tankage, separation, etc., on the land.

4. Combine the better features of the preceding methods with a minimum installation in the Gulf, lay a pipe line to shore, and erect tankage and treating facilities at that point.

The first method was quickly discarded because it was found that offshore tankage would cost approximately $50 per barrel as opposed to approximately $5 per barrel on shore. Tanks on structures, tanks incorporated in the structures, square tanks, underwater tanks—all were considered, but the per barrel cost did not vary appreciably with any of them. Also, the shallow waters in the vicinity of the wells precluded the use of even a small tanker, so it would be necessary either to use an oil barge or to lay a submarine line to deep water to meet the draft requirements of a tanker.

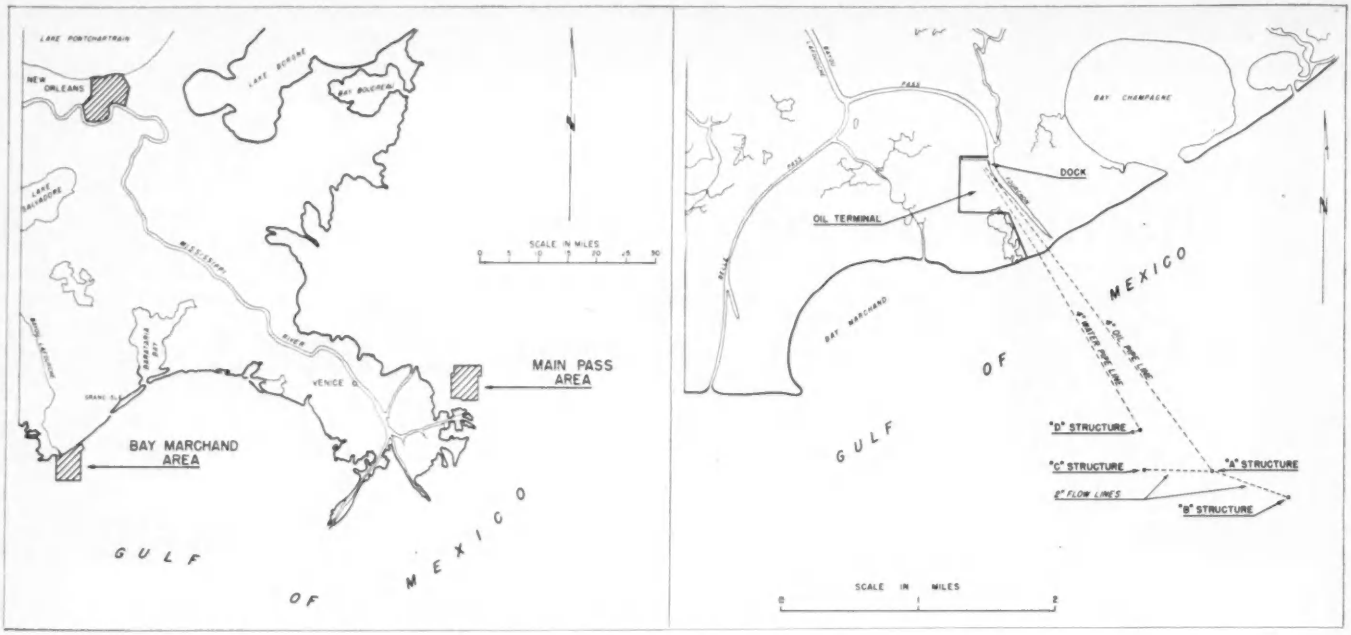
During this period of study and planning, the first wells were completed as producers and it immediately became obvious that the second and third methods were not practical. They not only would be unsatisfactory but also uneconomical. Producing into a barge was ruled out because of the experiences gained in bringing in the first wells. Mooring of barges alongside the structure was found to be expensive, troublesome, hazardous, and very unreliable. Heavy seas caused extensive damage to barges, structures and LSTs. Production was haphazard at best, with 25 percent of the producing time lost by having to search for the barge and pull it off the beach after rough weather had caused it to break loose. The dangers encountered by the men in keeping the barge moored and in producing into it could not be ignored, nor could the 80 cents per barrel cost in transporting the crude to New Orleans.

Flow lines to shore were lightly considered initially, and when the first wells were completed it was obvious that this method could not be adopted because of the distances involved, the low pressures, and the sanding conditions of some of the wells.

Method Adopted

The fourth method, consisting of minimum facilities offshore and a pipe line to a shore terminal, was finally adopted after considerable experimenting in the Bay Marchand field.

This field is 50 miles west of the mouth of the Mississippi River. There originally were three drilling structures approximately 3000 feet apart on a line



roughly parallel to the shore. The center structure was designated as "A," the easterly structure as "B" and the westerly structure as "C." A dry hole had been drilled from the center structure, which had been located directly on top of the dome. This is the largest true salt dome in the world (in spite of the claims of the Russians). Drilling from that structure was abandoned and the rig removed but the structure remained in place.

When the first wells were completed on the remaining two structures, a separator was installed beneath the drilling floor with a gas discharge line run up the derrick and an oil discharge line going directly to a barge moored alongside the structure. This was admittedly a very unsatisfactory arrangement and the dangers were not underestimated. In fact, the realization of them was intensified by another operator's disastrous blowout and fire in the Main Pass field in which one well, the structure, drilling barge, and several other barges disappeared beneath the waters.

It was resolved that production and drilling must be separated by installing a tank battery on the abandoned structure in the center, which henceforth would be the production structure. Space was limited, but two 250-barrel tanks, a high-pressure separator, 2 low-pressure separators, a 10-well header, regulators, meter runs and a doghouse were all placed on this 24 x 56 foot platform. It was planned to run two-inch flow lines from the "B" and "C" platforms to this production structure, install flow line safety valves at the beginning of the line near the christmas trees, and control all the wells from the one central point.

During the installation of this equipment the first two-inch flow line was being laid from a temporary wooden deck built on the lower braces of the production structure. It was believed that this line could be made up at this structure and pulled to the "B" structure by a wire line attached to a sand reel on the LST anchored there.

Unsatisfactory Method

Little difficulty was experienced in this process, but it was obvious that this method was unsatisfactory and uneconomical. The restricted area of the platform imposed difficult working conditions. The pipe, welding machines, rollers, joint materials, etc., allowed little room for welding the pipe together one joint at a time. As soon as a joint was welded orders were given over a portable FM radio to the winch operator to pull on the line. He was stopped at the appropriate time and another weld made. The previous joints were being doped and wrapped while welds were being made. Having to run the pipe over rollers into 30 feet of water placed undesirable stresses in the pipe; one joint broke and another was so badly bent that it had to be replaced.

All these factors, plus the danger, difficulty and time consumed in transferring men and materials from boats and barges to the temporary decking made it obvious that there must be a more satisfactory method of pipelining in the Gulf.

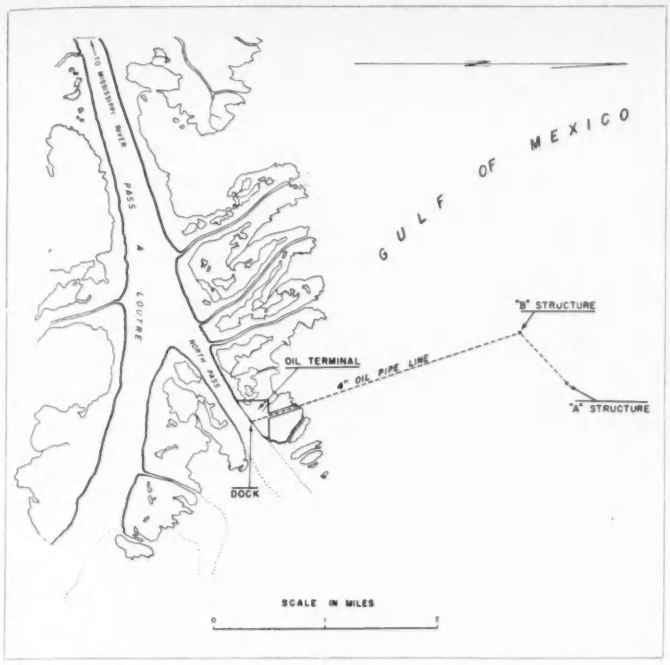
Two other methods were thereupon tried simultaneously. Another two-inch line was laid from the "B" structure to the production structure by running the winch line from the ship to the production structure, through a block and then back to the LCT. A chute was built on the side of the ship, welding and doping were done on the ship and the line pulled from the ship to the production structure.

Outside of relieving some of the stress on the line, this method was only slightly more economical than the first, but the third one indicated definite promise.

That line was made up of triple sections previously welded up at the terminal under good working conditions in sheltered water. These sections were welded together on a barge, doped and wrapped, and the barge then pulled ahead as the welds were made allowing the pipe to slide off and rest on the bottom of Belle Pass, a convenient bayou approximately 2½ miles from the structures. When the entire line was completed two marker buoys were tied on each end and arrangements made to tow it into position. Experience is a great teacher and generally these lessons are learned in a hurry. Ours was. Sufficient stress was exerted upon the line to pull it in two, but it still would not move until it was raised slightly and loosened in several places. The ebb and flow of the tidal currents in Belle Pass had caused sufficient disturbance on the bottom to bury the line.

Subsequent lines were laid essentially in the same manner as the previous method except that the pipe line was suspended from buoys—oil drums approximately 100 feet apart. A rope sling with a slip knot on top of the drum provided a quick method of lowering the line into position. A work boat ran along the line of buoys untying the ropes and a converted LST followed to retrieve the buoys. The pipe lines tow very easily after they have started; in fact, some of the recent 3000-foot lines have been installed completely in one eight-hour day.

During this time production was building up, and the production structure and



LEFT: The Bay Marchand Area west of the Mississippi Delta and the Main Pass Area to the East of the Delta, both shown in cross-hatch, were close enough to shore to justify the expense of underwater pipe lines.

CENTER: Detail of underwater pipe lines in the Bay Marchand field. Water stored in tanks on "D" structure eliminates expensive hauling charges from Grande Isle.

RIGHT: Main Pass area is served by a four-inch underwater oil line which terminates at the oil terminal with dock facilities in the Main Pass of the Mississippi Delta.

the flow lines were operating satisfactorily, but it was still costing one third the value of the crude to barge it ashore. Because the storage was so limited it was necessary to moor an oil barge alongside continuously, or as continuously as the waves and swells would permit, which as previously mentioned was only 75 percent of the time.

The ease and success with which the flow lines were installed indicated that a collection line could just as easily be laid from the production structure to a terminal on the shore. The general procedure in laying this 14,400 feet of four-inch oil collection line from the production structure to the location of the future 10,000-barrel oil tank on shore was essentially the same as that used on the fourth two-inch flow line. Conditions were imposed upon the construction of the four-inch line, however, which required a change in operations. First, the entire line could not be assembled and towed into position because 11,000 feet of it was in the Gulf and the remaining 3400 feet in the marsh. The second condition was that in shallow waters the U. S. Army Engineers require pipe lines to be buried at least three feet.

Here again, advantage was taken of the topography which was favorable to the work. Bayou Fourchon ran parallel to the portion of the line through the marsh and generally parallel to the projection of the seaward portion of the line. Bayou Fourchon had a navigable channel into the Gulf until it was closed at the shoreline by a 150-foot wide sand bar thrown up by a hurricane in 1934. It was accordingly decided to work from the inside as much as possible by dredging up to the beach at the mouth of the bayou and work both ways from the firm sand beach. It would have been necessary to use matting to support the men and equipment if the operations had been conducted from a point in the marsh.

After the dredging, the supply barge was pushed through the bayou to the beach and all the pipe, two welding machines, dope pot and a side-boom tractor were unloaded. The welders immediately began to double-joint the pipe, a labor crew cut a shallow ditch from the shore to the tank terminal, and the dragline which had done the dredging cut a channel from the bayou to the point where the pipe line was to intersect the shore. Considering the vagaries of the weather it was determined to weld up the seaward length of the line first, so that when a calm day should occur, after the completion, it could be towed out immediately.

Nine thousand seven hundred feet of pipe were welded together, suspended from 55-gallon oil drums at approximately 50-foot intervals, and pulled back into Bayou Fourchon. Flags were used to signal the tug when to pull and when to stop. When visibility was poor portable FM radio sets were used to give the orders. The remaining 1300 feet of the seaward length had to be pushed back into the marsh from the beach because Bayou Fourchon was not long enough to accommodate the entire length, and it was feared that if this 1300 feet was added and pushed into heavily traveled Bayou La Fourche that serious damage to vessels and line might possibly occur.

The dragline, being a small machine on a small barge, had had no luck whatever in attempting to excavate the trench in which the pipe was to be buried in the Gulf, so while a larger machine was en route, the 3400 feet of line in the land section was pushed into place in its guiding trench by the side boom tractor in the conventional manner.

When the large dragline arrived, weather conditions were not agreeable to its working outside so it was decided to pull the line out and then dig the trench later and lay the line over in it. A 600-horsepower rented tug and a 1000-hp converted California Company LCT were used in the pull, which took three hours from start to finish. First the 1300 feet were pulled until the shore end could be welded to the 9700 feet floating in Bayou Fourchon. As soon as this joint was completed the towing proceeded rapidly. Each buoy was removed as it came to the shoreline and thrown up on the beach so that the line would slide on the bottom and be less affected by the strong coastwise current. A long radius bend, to permit the passage of a

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scraper, was welded on the seaward end of the line before it was dropped to the bottom. This provided the riser to the pump platform which was constructed on the fender jacket adjacent to the production platform. On a calm day the pipe was placed in its trench in the Gulf by the large dragline, using a bridle and pipe line clamps. The back-filling was done by the ocean currents. A 1500-pound hydrostatic test held on the line for 24 hours completed the installation.

Meanwhile a 700-barrel per day production rate had been established at Main Pass with prospects of several hundred barrels more at an early date and more to progressively follow. A 50 cents per barrel saving on transportation of this crude was obvious justification of another line from the Main Pass "A" structure to the "B" structure (yet to be drilled) and thence to a shore terminal on North Pass.

Laying the Line

This line was laid simply by welding 3000-foot sections and pushing them across the 3000-foot neck of marsh between North Pass and the Gulf. The pushing side-boom tractor, the welders and joint men worked from one barge while pipe, welding machine and radios were on another tied alongside. Both barges were anchored perpendicular to the shore. It should be noted that one 4200-foot section was first laid on the bottom of North Pass upstream from the anchored barges.

During the welding of the 3000-foot sections, a dragline on a spud barge had been digging the required channel to bury the pipe in the Gulf. This equipment started at the seaward end and worked toward the shore. When the trench was completed the spud barge backed up 3000 feet, paying out a winch line. The barge then anchored, the winch pulled one section of pipe, another section was acetylene-welded, and the process was repeated until the water became too deep for the spuds. At this point, the spud barge was moored to the "B" structure, the 4200-foot length lying on the bottom of North Pass was welded to the last 3000-foot length to be pulled through the marsh and a 7200-foot pull was made completing the section from the "B" structure to the future shore terminal. The total length of this portion is 16,200 feet.

With excellent weather at this time and the remaining pipe having been welded into sections approximately 90 feet long, it was decided to complete the 3800 feet between "B" and "A" structures from barges. The work barge was tied to the "B" structure, and a barge with an end winch tractor on deck was tied to the "A" structure. The winch barge pulled as directed by radio and welded pipe was payed out from the work barge at the "B" structure. With only 45 welds to make, very little time was consumed in this operation. However, this process is not recommended except under the most ideal conditions, which seldom exist.

There were unexpected results on the first test of this line. No pressure could be built up and the reason became apparent when an 18-inch split was found just at the shoreline. Since the entire line was of butt-welded pipe there were immediate visions of splits for the entire length but only three other small leaks were found, and, of course, air pressure had to be used to find them.

The final test, to be a little more on the safe side, was reduced to 1300 pounds, and this was held satisfactorily for 24 hours.

The California Company has laid to date, in the Gulf of Mexico, three 4-inch lines (the third being laid at Bay Marchand in the same manner as the first) with a total length of 47,900 feet; and eight 2-inch lines with a total length of 23,800 feet. These lines are operating satisfactorily, but it is realized that there are many problems yet to be solved and better solutions obtained to those already encountered. The major problems appear to be more economy in installation; properly anchoring or marking the lines to prevent damage; corrosion control; repairing underwater damage; and correct type of scrapers to be used.

More economies in the installations of these lines can no doubt be achieved. This is evidenced by the fact that costs have been reduced on the last lines by 20 percent on the four-inch and by 45 percent on the two-inch, but these costs are still approximately four times that of laying comparable lines in the marshes. It should be mentioned that a large part of the cost on any line in shallow water is due to the burying required by the U. S. Engineers. Until the burying problem in shallow waters is further improved costs will probably remain high.

In the Main Pass field the pipe lines buried themselves in the soft bottom as they were pulled into position. In contrast to this there is evidence that the lines in the Bay Marchand field have moved with the current. The bottom is hard blue clay, the lines have not buried themselves, and coastwise currents as high as six miles per hour have been observed. Generally, these currents move to the west but at times they move toward the east. Under these conditions the problem of marking the Main Pass lines is simple. Spar or nun buoys at 1000-foot intervals should suffice to prevent damage from dragging anchors. At Bay Marchand the first line laid has been damaged twice by dragging anchors in spite of the vigilance exercised. It is probable that river clamps or some sort of line anchors will be needed in addition to marking buoys to prevent recurrence of such accidents.

All lines installed have been coated and wrapped as they would have been had they been installed on land. It is not yet known if this is the proper coating because it is very probable that it may be damaged by marine life. The extent of this damage, if any, cannot be anticipated.

Protecting Lines

Corrosion is expected to be extensive unless cathodic protection is installed. Lines have been prepared for this protection by coating and wrapping and by installing insulating flanges at either end. Due to the absence of a steady supply of electrical current, which would be required if graphite anodes were used, it seems certain that the initial protection will be furnished by magnesium anodes.

All underwater damage and leaks in the four-inch lines have been repaired by using a derrick barge. The general method was to support the line in several places, cut out and replace the damaged section, and then lower the line to its original position. Several of the two-inch lines have suffered minor damage but the leaks were repaired by using clamps installed by a diver. Underwater welding has been tried, but test coupons indicated unsatisfactory welds.

It is hoped that the very warm water temperatures prevailing on the Gulf floor, even in winter, will tend to minimize paraffin troubles. It is planned to use plugs soluble in oil as scrapers but scrapers with radioactive noses have also been considered. It would be practically impossible to locate a scraper lodged in a line in 30 feet of water without some help.

Every new line in a different location will be a distinctly separate problem. The length of the line, the topography of the country adjacent to the shore, and the amount of line to be buried appear to be the controlling factors as far as the methods used are concerned. One thing is certain—the more work done inside the shoreline the less will be the cost and the danger outside. There is presently no reason to believe that longer and larger lines cannot be laid in the Gulf of Mexico with equal facility.

The Cranfield Unit

Cycling-Pressure Maintenance

Part 1 - BASIS OF THE UNITIZATION AGREEMENT

By LEO E. HINES
Division Production Engineer, The California Company

THE Cranfield field's unitization agreement between Placid Oil Company, Gulf Refining Company and The California Company includes those known gas and oil producing sands of the Tuscaloosa and Paluxy formations.

The Tuscaloosa formation of Upper Cretaceous age is continuous throughout South Arkansas, North and Central Louisiana and Mississippi; further, it is apparently porous throughout most of this region. However, due to the presence of large amounts of chloritic material in this sand and local shaly areas, the effective permeability of this horizon is low. As a consequence, the prospect of a water drive of commercial magnitude in this sand is unlikely.

The Paluxy formation of Lower Cretaceous age is a blanket sand extending over Mississippi, Louisiana, South Arkansas and East Texas.

Figure 1[1] illustrates the stratigraphic correlation of the Tuscaloosa and Paluxy formations on the Gulf Coast.

In August, 1943, the National Gasoline 1 well discovered the Basal Tuscaloosa sand gas cap in the Cranfield field, at a depth of approximately 10,300 feet. Later drilling showed this well to be located in almost the geometric center of the structure. This discovery led to the drilling of 78 additional wells to the Basal Tuscaloosa sand by mid-1947. Three of these wells were drilled to the Paluxy, a deeper horizon; however, only one well was completed in this formation. Original completion and test data showed eight of these wells to be gas cap producers, 67 oil producers and three dry holes.

The Cranfield structure proved to be almost circular in areal extent. The Tuscaloosa reservoir was found to have a very large gas cap, comparatively speaking, with a narrow oil band that completely encircled the gas cap.

By examining the specific well locations (Figure 10) relative to structural position, it becomes apparent, from a geometric standpoint, that this "layout" of drilled wells would be conducive to an efficient gas flood of the sand. Moreover, the operation could be effectively completed, from a recovery standpoint, by producing both the oil band and gas cap simultaneously, while at the same time injecting the residue dry gas from produced products into the top or center of the pool. Further, the time saved by producing the oil band and gas cap liquid hydrocarbon reserve together would greatly lower ultimate lifting costs, since under normal depletion methods, the gas cap would probably have remained "shut-in" until all recoverable oil band material had been extracted. Until August 31, 1947, the official date of unitization, this was the general field production plan, that is, the gas cap wells were shut-in, and only oil band wells were produced. High gas-oil ratio wells were closely controlled in production to conserve reservoir energy, eliminate waste, etc.

TABLE 1
AVERAGE GAS CAP RESERVOIR MATERIAL ANALYSIS AND RECOVERY CALCULATIONS
Cranfield Field, Mississippi
Basal Tuscaloosa Formation

Comp.	Mol. %	G/M
CO_2	2.81	
C_1	79.91	
C_2	6.49	
C_3	2.75	.754
iC_4	.62	.202
nC_4	1.03	.324
iC_5	.63	.230
nC_5	.47	.170
C_6	1.17	.480
C_7+	4.13	2.374
	100.00	4.534
Molecular Weight C_7+		142.5
Sp. Gr. of C_7+		.7857
Vapor Equivalent of C_7+ $\left(\frac{379 \times 8.3283 \times .7857}{142.5}\right)$ cu.ft./gal.		17.4
Formation Compressibility Factor (z) Determined		.960
Basic Data Gas Cap		
Average porosity		25.5
Average interstitial water		47.3
Average reservoir pressure PSIA		4701
Average reservoir temperature °F.		263
Reserves Gas Cap Material		
Ac. Ft. of Basal Tuscaloosa gas sand		238,222
Sand pore gas saturation MCF/Ac. Ft. (dehydrated)		1,395
Gas cap liquid condensate, Bbl./Ac. Ft.		98.47
Volume of Reservoir Gas in Place, MCF		332,319,000
Total Gas Cap Condensate*, Bbls.		23,458,000

* See "Definition of products"

Characteristics of Basal Tuscaloosa Sand and Reservoir Fluids

Figures 2, 3, 4 and 5 indicate the various gas cap and black oil band reservoir parameters. Further, from the slope of Figure 4 it is obvious that unless some effort is made to conserve reservoir pressure early in the producing life of the pool, large volumes of liquefiable hydrocarbons, which would otherwise be recoverable should pressure be maintained, will be lost in the sand due to retrograde condensation.

It is generally a foregone conclusion, in the oil industry, that a company may operate much more efficiently from both a recovery and economic standpoint, if its and surrounding properties are unitized. This is true, in part, since the over-all lifting cost of produced products will be lower in a unitized project than in competitive operation. In general, a unitized project contains all the desirable features of a complete production operation. However, regardless of the advantages of unitization over competitive operation, it is an impossibility to unitize a sand unless equity is established between all operators, likewise, royalty owners. As the result, those projects which have been successfully unitized in the past have adopted methods of distribution and recovery which will best establish equity among all operating and participating owners.

In the effort to unitize the Cranfield

field, Basal Tuscaloosa and Paluxy sands, Placid Oil Company, Gulf Refining Company and The California Company have managed to adopt methods whereby resulting calculations, etc., established equity to the satisfaction of practically all. It is believed that the Cranfield project is the first successful plan whereby both black oil and gas cap acreage owners are unitized into one producing agreement. Further, in the operation of subject agreement the produced condensate and black oil are processed to the plant and co-mingled. Each company and royalty owner is then paid in proportion to his calculated participation factor. An explanation of methods and calculations used in establishing equity among participants of the Cranfield field Unitization Project follows:

Methods of Effective Sand Determination in Basal Tuscaloosa Formation

The effective Basal Tuscaloosa sand was determined from electric logs of each well penetrating the formation. Further, in order to better evaluate the effectiveness and productivity of the three sand members, of which this sand essentially consists, core analysis reports, conventional and wireline core descriptions, results from drill stem tests, and side wall core samples were used in conjunction with the electric logs.

Core data established the gas-oil and water-oil contacts as —9976 and —10,066 respectively. These and other data estab-

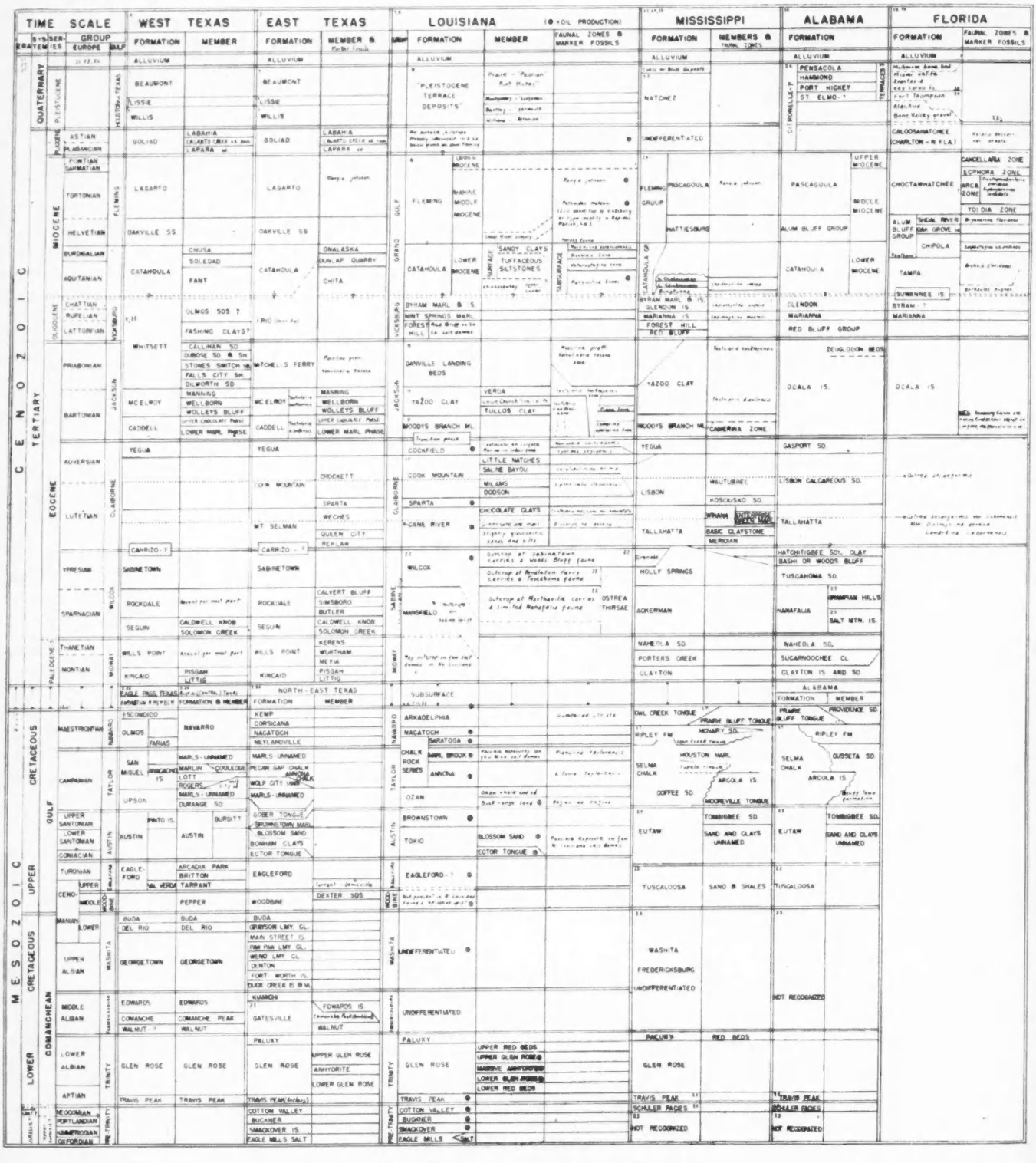

FIGURE 1. Stratigraphic section of the Gulf Coast.

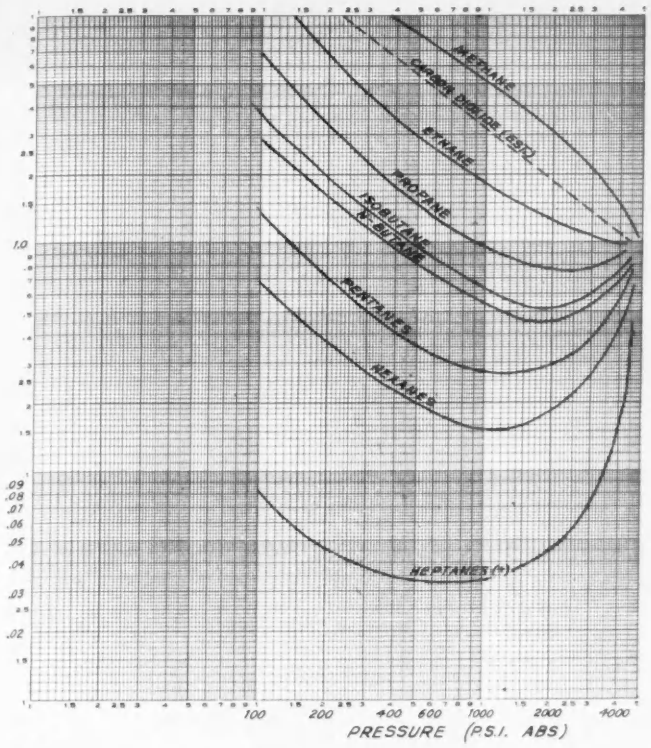

FIGURE 2. "K" values determined for reservoir field of Basal Tuscaloosa.

Equilibrium constants for Cranfield oil field effluent at formation temperature 264° F.—effluent composition.

	Mol %
CO_2	2.88
Methane	79.93
Ethane	6.58
Propane	2.72
Isobutane	0.69
N-Butane	1.04
Pentanes	1.10
Hexanes	1.03
Heptanes (+)	4.03
	100.00

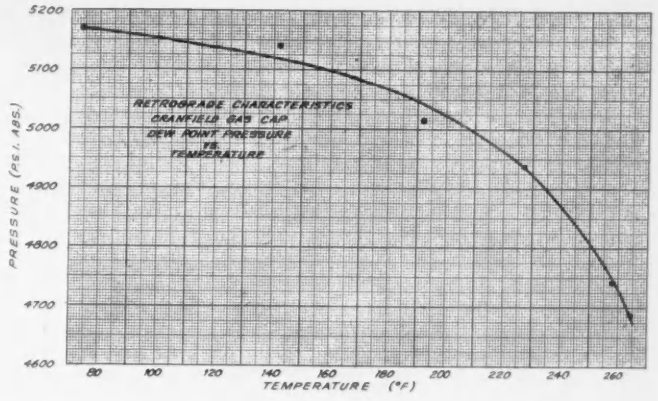

FIGURE 3. Dew point curve for the gas cap.

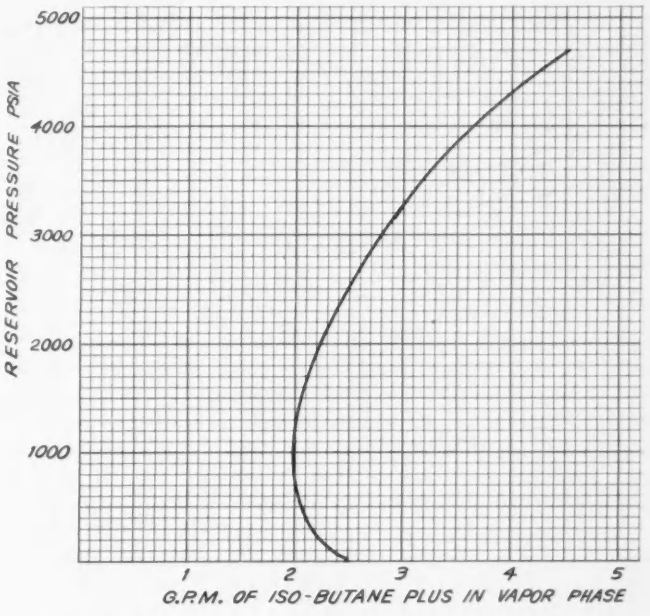

FIGURE 4. Retrograde condensation curve for the gas cap.

TABLE 2[1]

Gas Cap Material Natural Depletion Summary of Recovery Calculations Gas to 300 psia

Comp.	Original Composition		In Reservoir @ 300 PSIA		Recovered		
	Mol. %	G/100 MCF	MCF	Gals.	MCF	G/100 MCF	% Recovery
CO_2	2.81	....	.1635	....	2.6465	....	94.18
C_1	79.90	....	4.5450	....	75,3500	....	94.31
C_2	6.49	....	.3900	....	6.0910	....	93.99
C_3	2.75	75.4	.1837	5.0	....	70.36	93.32
C_4	.62	20.2					
iC_4	1.03	32.4	.1294	4.124	....	48.48	92.16
C_5	.63	22.8	.0612	2.21			
iC_5	.47	17.1	.0457	1.67		234.00	71.89
C_6	1.17	48.0	.1538	6.30	....		
C_7	4.13	237.4	1.4120	81.12			
	100.00	453.4	7.0843	100.46			

TABLE 3[1]

Gas Cap Material Natural Depletion Calculated Volumes of Liquid and Gas Phases of Unrecovered Hydrocarbons 300 psia Abandonment Pressure

Comp.	MCF	Gals.	In Vapor Phase		In Liquid Phase
			MCF	G/M	MCF
CO_2	.1635	....	.1584	....	.0051
C_1	4.5450	....	4.4000	....	.1450
C_2	.3900	....	.3690	....	.0210
C_3	.1837	5.040	.1622	.806	.0215
iC_4 / nC_4	.1294	4.124	.1075	.626	.0219
iC_5	.0612		.0405	.263	.0207
nC_5	.0457	91.300	.0303	.200	.0154
C_6	.1538		.0784	.582	.0754
C_7+	1.4120		.1730	1.803	1.2390
	7.0843	....	5.5193	4.280	1.5650

lished whether or not the sand was effective oil, gas or water bearing.

The general geology of the Basal Tuscaloosa formation is typified by Figures 7, 8, 9, 10, 11 and 12. Presented isopach maps indicate three sand lens; however, in many places these indicated sand lens coalesce. In the Cranfield field these production sand lens are called the upper, middle and lower members of the Basal Tuscaloosa formation. Upper member of the Basal Tuscaloosa and Paluxy sand lens isopach maps are not shown. Figure 12 is the structure map of the top of the Basal Tuscaloosa formation. A time equivalent correlation, based upon a resistivity characteristic found in The California Company's Ella G. Lees 9 at 9991 feet, was used to construct the Basal Tuscaloosa structure map. One hundred and thirty-nine feet were added to the subsea elevation of this point in order to approximate the top of the main sand body. Figure 6 indicates the geologic interpretation of the E. G. Lees 9 electric log. This time equivalent correlation point is present

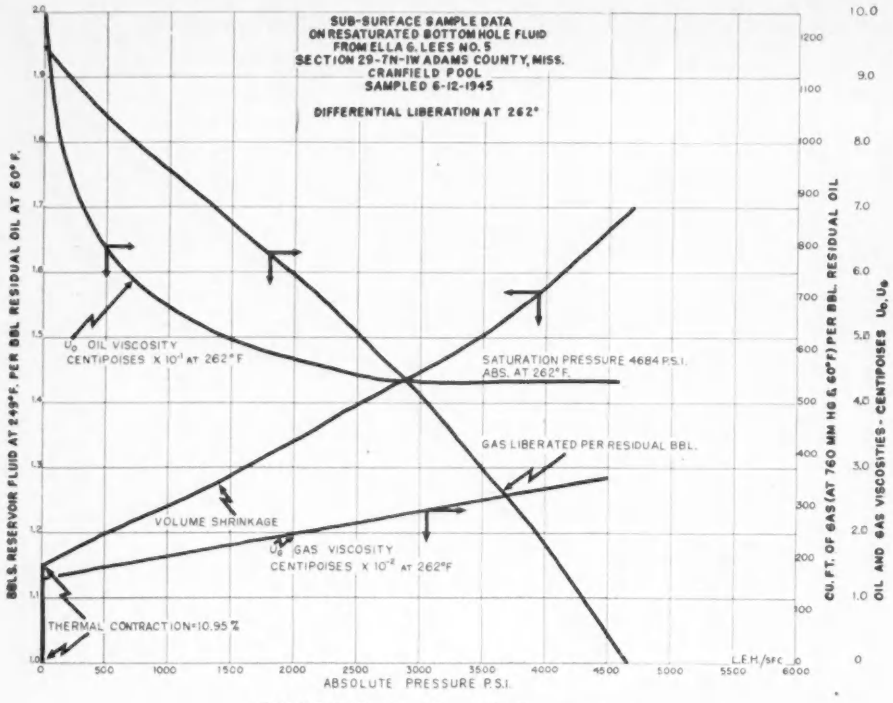
SUB-SURFACE SAMPLE DATA
ON RESATURATED BOTTOM HOLE FLUID
FROM ELLA G. LEES NO. 5
SECTION 29-7N-1W ADAMS COUNTY, MISS.
CRANFIELD POOL
SAMPLED 6-12-1945
DIFFERENTIAL LIBERATION AT 262°
BBLS. RESERVOIR FLUID AT 249°F. PER BBL. RESIDUAL OIL AT 60° F.
CU. FT. OF GAS (AT 760 MM HG & 60°F) PER BBL. RESIDUAL OIL
OIL AND GAS VISCOSITIES - CENTIPOISES U_o, U_g
U_o OIL VISCOSITY CENTIPOISES X 10^{-1} AT 262°F
SATURATION PRESSURE 4684 P.S.I. ABS. AT 262°F.
GAS LIBERATED PER RESIDUAL BBL.
VOLUME SHRINKAGE
U_g GAS VISCOSITY CENTIPOISES X 10^{-2} AT 262°F
THERMAL CONTRACTION=10.95 %
ABSOLUTE PRESSURE P.S.I.

FIGURE 5. Black oil band fluid parameters.

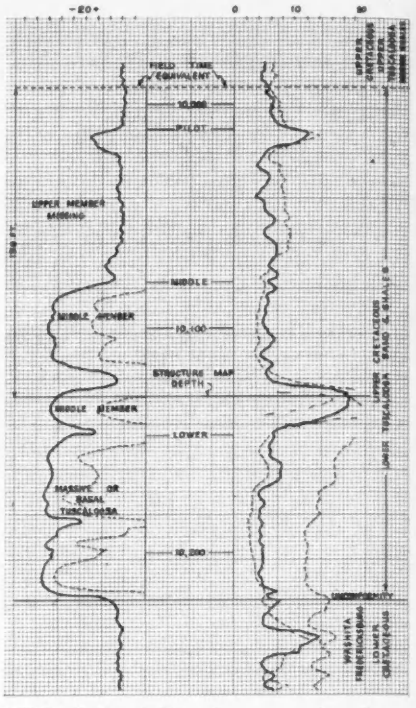

FIGURE 6. Basal Tuscaloosa mapping datum time equivalent.

over most of the region in which the Tuscaloosa has been mapped.

Isopach maps of the total effective sand of each of the three sand members were made in order to show the areal and thickness distribution over the entire field. Oil and gas isopach maps were then constructed for each sand member by combining the structure, total isopach maps, gas-oil contact and water-oil contacts.

Oil isopach maps were constructed for each sand member, using the sand development in the wells (total isopach) and establishing two zero contours by projecting the top of the sand to the oil-water contact and the base of the sand to the gas-oil contact at the rate of dip indicated by the structure map.

Gas isopach maps were constructed in a similar manner to that explained for the oil isopach, except the one zero contour was established by projecting the top of the effective sand in the wells to the gas-oil contact. Regulation of the other contours was made by structural dip and total isopach, that is, until the maximum thickness of the effective sand had been attained. The contours of the total isopach became identical with those of the gas isopach at this point.

The Paluxy, like the Basal Tuscaloosa, in the Cranfield field, Mississippi area, is made up of three sand members; how-

TABLE 4

Average Black Oil Band Material Reservoir Analysis and Recovery Calculations, Cranfield Field, Mississippi, Basal Tuscaloosa Formation.

		BLACK OIL WELLS—LIBERATED SOLUTION GAS			
		From Produced Oil		From Unrecovered Oil	
Comp.	Mol. %	Mol. %	G/M	Mol. %	G/M
CO_2	1.84	2.71	....	2.61	....
C_1	53.86	80.60	....	79.31	....
C_2	7.17	10.30	....	9.22	....
C_3	3.34	3.71	1.018	3.62	.993
iC_4	1.04	.78	.254	.93	.303
nC_4	1.58	.97	.305	1.26	.396
iC_5	1.23	.34	.124	.74	.270
nC_5	.95	.22	.080	.51	.184
C_6	2.48	.27	.111	.96	.394
C_7+	26.61	.10	.089	.84	.751
	100.00	100.00	1.981	100.00	3.291

Molecular Weight of C_7+	240.4
Specific Gravity C_7+	.8491
Vapor Equivalent of $C_7+ \left(\frac{379 \times 8.3283 \times .8491}{240.4}\right)$ cu. ft./gal.	11.19
Basic Data Black Oil Band:	
Average porosity	25.5
Average interstitial water	47.3
Average reservoir temperature °F.	263.
Average original reservoir pressure PSIA	4701.
Original formation volume factor	1.6116
Original solution GOR	1074.
Reserves Black Oil Band Material:	
Acre-Feet of Basal Tuscaloosa black oil sand	169,924
Recoverable tank oil[3] in place 8-30-48, Barrels	49,271,000
Solution gas from both recoverable and unrecoverable oil, MCF	86,984,000

TABLE 5

AVERAGE PALUXY FORMATION RESERVOIR MATERIAL

Analysis and Recovery Calculations
Cranfield Field, Mississippi
Paluxy Formation

Comp.	Mol. %
CO_2	7.50
C_1	92.25
C_2	.08
C_3	.03
C_4	.02
C_5	.05
C_6+	.07
	100.00

Basic Data

Average porosity %	14.2
Average interstitial water	42.0
Average reservoir temperature °F.	303.0
Average reservoir pressure PSIA	5440
Original reservoir gas compressibility factor	1.15
Abandonment pressure (reservoir) PSIA	1000

Paluxy Sand Reserves

Ac. Ft. of Paluxy Formation gas sand	46,212
Sand Pore recoverable gas saturation, MCF/Ac. Ft. (dehydrated)	653.97
Sand pore gas saturation available for injection, MCF/Ac. Ft.	601.65*
Gas available for injection or sale, MCF	27,803,000

* Recoverable gas in place less gas to be used in operations.

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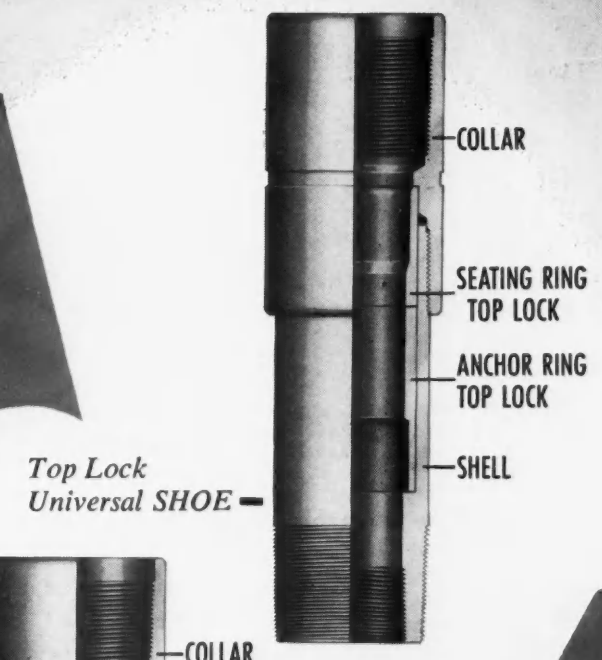
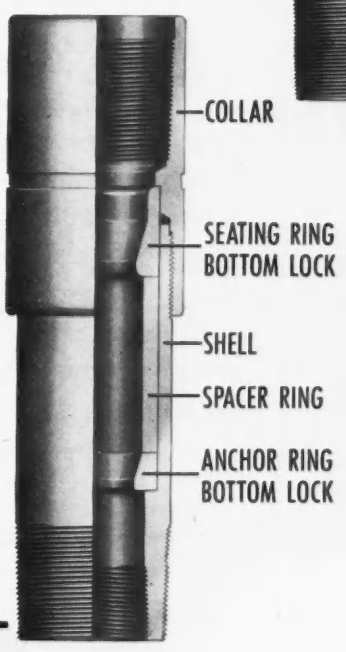


Top Lock Universal SHOE



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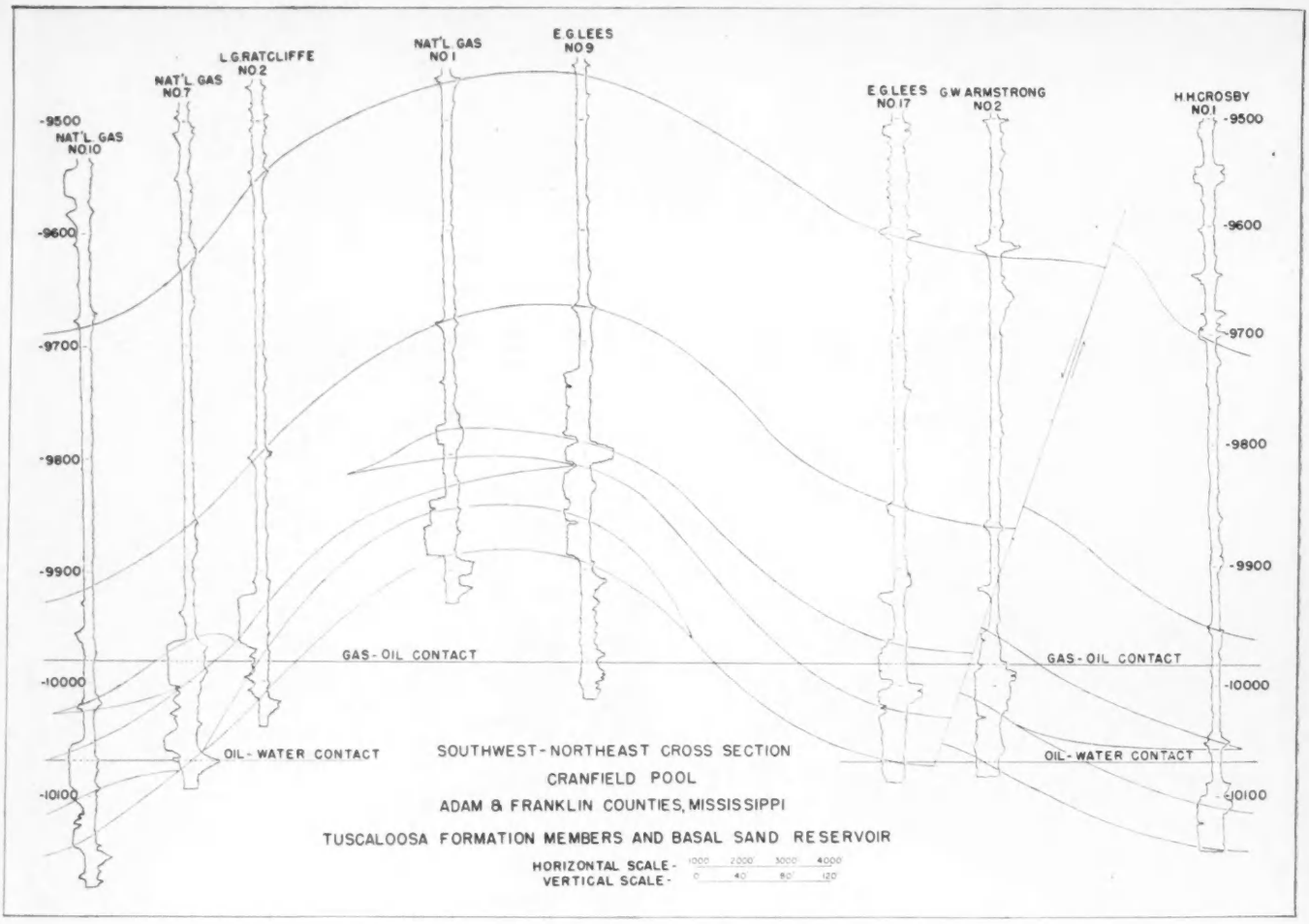

FIGURE 7. Cross section of Basal Tuscaloosa sand, Cranfield, Miss.

ever, these sand members coalesce in numerous places. Further, the effective sand in the Paluxy formation is based upon the same sources of data as indicated in detail for the Basal Tuscaloosa; however, different limitations had to be established due to the marked difference of the two zones.

Core data and drill stem tests established that a normal resistance of 20 ohms opposite the maximum self potential of the sand body was necessary for gas production. Those sand intervals of wells with less resistivity were considered water productive only.

Production and core data in the Cranfield area show the Paluxy formation to contain a very dry gas as its only hydrocarbon pore saturating fluid. (See Table 3 for analysis.)

Measuring and Calculating Productive Sand Volumes

Both the oil and gas sand isopach maps for each member and sand were constructed using ten-foot contour intervals. In order to obtain as much accuracy as possible in the planimeter work to be performed on each lease or tract, each map was completed on a scale of 1 inch equals 500 feet. The number of acre feet of effective sand allotted to each tract was established by planimetering the inclusive areas be-

TABLE 7

Calculation of Unit's Composite Value

	Value per Ac. Ft.	Ac. Ft.	Dollar Value
Basal Tuscaloosa Sand Black Oil Zone	697.09	169,923.75	$115,395,218.86
Basal Tuscaloosa Sand Gas Cap	334.61	238,222.38	79,711,590.57
Paluxy Formation Gas	36.94	46,212.23	1,707,079.78
Composite Value			$196,813,889.21

This composite value was then used as a total relative to all leases in the Cranfield Field Unit Agreement. Participation factors for each individual lease or tract were determined by dividing the above composite value into a similarly calculated composite value for each individual lease or tract in the Unit.

On the basis of these methods, resulting recovery factors, geologic information, and price data presented, the Gulf Refining Company, Placid Oil Company and The California Company made an agreement to unitize the sands previously indicated. This unitization agreement became effective August 30, 1947, with The California Company as the unit operator.

TABLE 6

Summary of Gas Cap and Tank Oil Zone Recovery Factors and Price Data Example of Monetary Value Calculations

BLACK OIL ZONE

PRODUCT	Recovery Bbls./Ac. Ft.*	Unit Value Dollars	Value Per Ac. Ft.
Tank Oil Bbls.	289.96	2.0415	591.95
Condensate Bbls.	14.41	2.2465	32.37
Butanes Bbls.	8.03	1.6135	12.96
Propane Gals.	266.95	.0450	12.01
Dry Gas MCF	485.41	.0614	29.80
Total Value			679.09

GAS CAP

PRODUCT	Recovery Bbls./Ac. Ft.*	Unt Value Dollars	Value Per Ac. Ft.
Condensate Bbls.	98.47	2.2465	221.21
Butane Bbls.	15.42	1.6135	24.88
Propane Gals.	460.71	.0450	20.73
Dry Gas MCF	1104.10	.0614	67.79
Total Value			334.61

PALUXY FORMATION GAS

PRODUCT	Recovery Bbls./Ac. Ft.*	Unit Value Dollars	Value Per Ac. Ft.
Dry Gas MCF	601.65	.0614	36.94
Total Value			36.94

* All recovery values reflect respective formation abandonment pressures.

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tween contours on each tract. This area was then multiplied, in acres, by the average of two bounding contours. All such values for a lease or tract were then added for a total value of acre feet in the tract.

Planimetering the various tracts of the Cranfield unit demanded extreme care and accuracy since the resulting values, in part, would control the "pay off." Several of the features of the planimetering would bear mentioning. Planimeter readings for the total tract areas were corrected to equal the actual survey of the tract. Further, in order that individual planimeter contour readings, measured within a tract, would have as much accuracy as possible, three readings of the same area were made; each of these readings would then have to check within a very small percentage.

Tract reserves were then calculated by multiplying the results of these tract volumes (Ac. Ft.) by the calculated recovery factors for each type product in place.

Interstitial Water Determination

The sand pore interstitial water percentage was estimated from core data. Estimations were made by a reliable core analysis service company. In order to establish an average value for the field, information was taken from ten cored wells. Structurally, the wells were located in all quadrants of the reservoir. The weighted average interstitial water value for the Basal Tuscaloosa sand was 47.3 percent of the porosity. Since this value was established, two additional oil band wells have been drilled using straight oil base mud for the coring fluid. Core analysis interstitial water data from these wells indicated the validity of the previously established value of 47.3 percent. For the Paluxy forma-

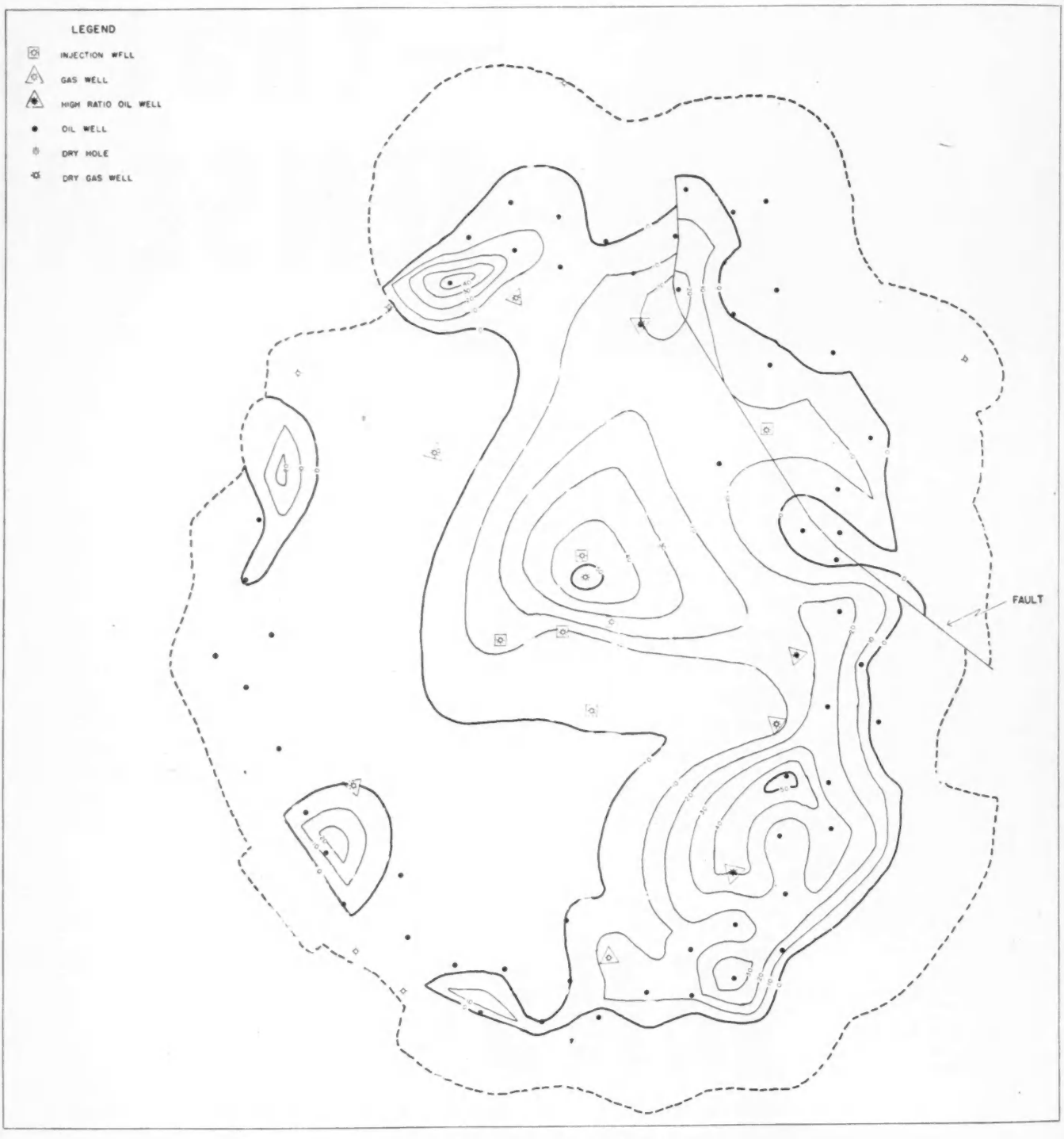

FIGURE 8. Middle member gas isopach.

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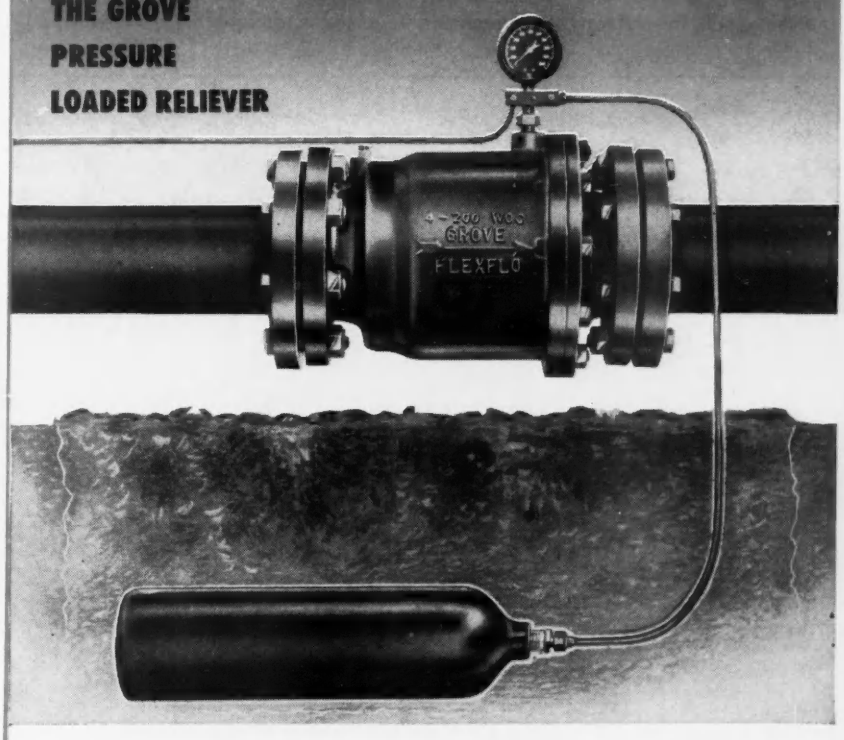

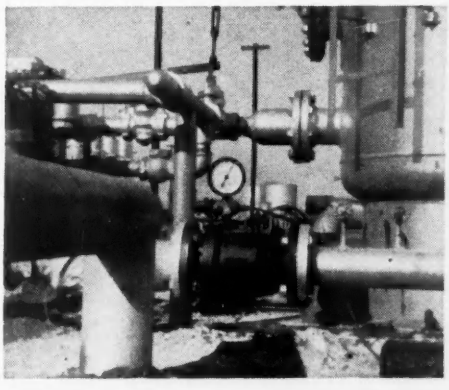

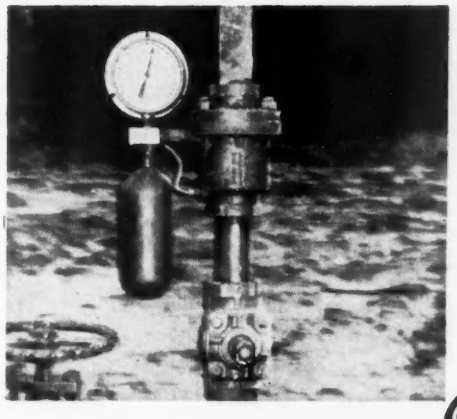

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tion, this value was 42.0 percent of the porosity.

An effort was made to estimate interstitial water content using resistivity curves on the electric logs; however, due to the exceptionally low resistivities measured, it was concluded that the accuracy of point to point interstitial water calculations from electric logs would not approach that of actual core analysis data. In certain cases, however, it was found the results of both methods checked very closely. (Formation water of the Basal Tuscaloosa sand has approximately 138,000 parts per million chloride content, plus the existence of a relatively high pore volume percent of interstitial water content. These two facts are thought to be the reason for the exceptionally low resistivity readings generally observed on the electric logs in the Cranfield field, Mississippi.)

Contained in each recovery factor of the Cranfield agreement, whether for gas cap or oil band material, certain controlled assumptions have been made. These assumptions parallel and compare to those assumptions generally made in other valuations. In short, these assumptions were taken from a theoretical treatment of the problem, the geological characteristics of the Tuscaloosa structure and experiences of other operators

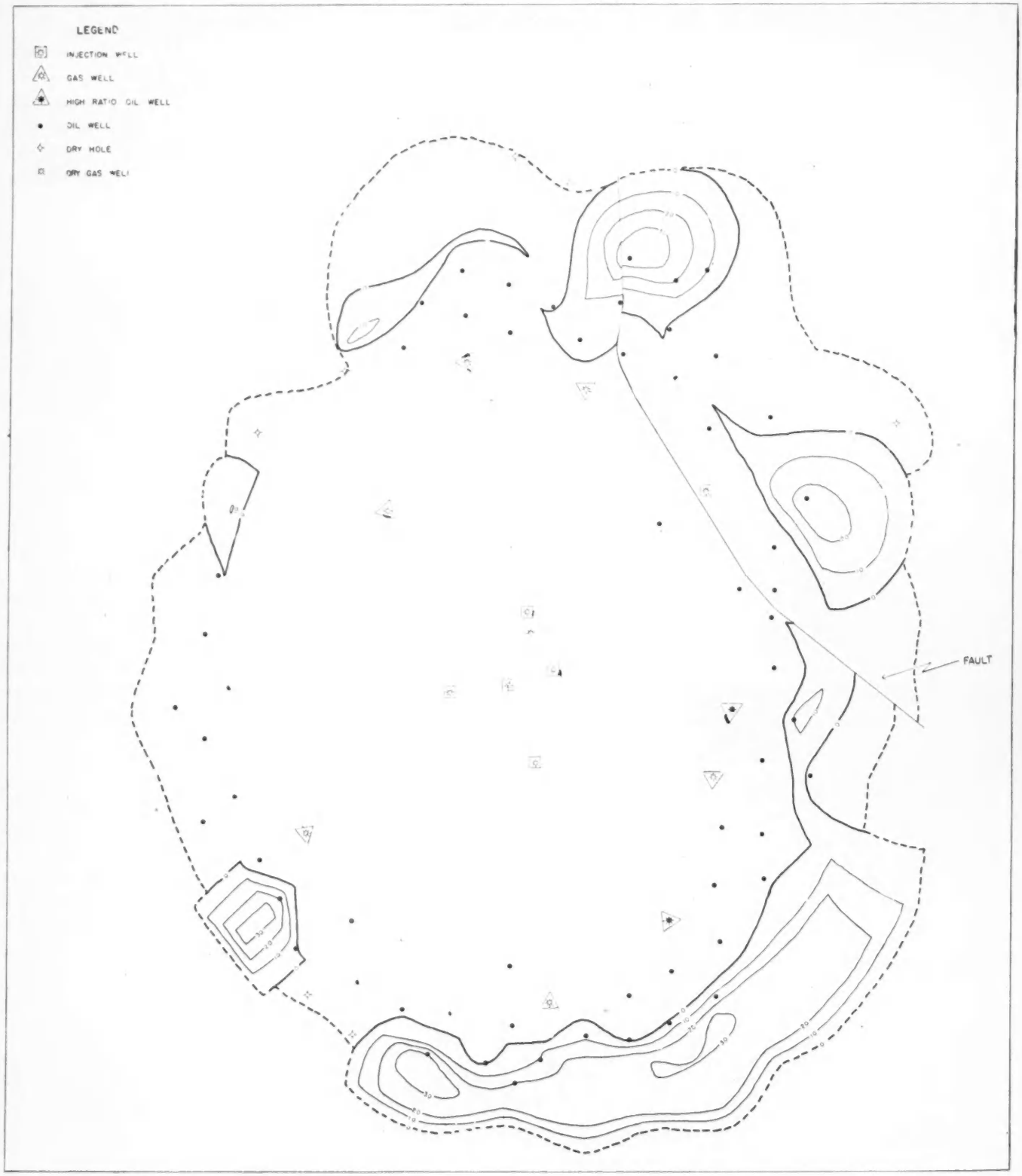

FIGURE 9. Middle member oil isopach.

Free Pumping

LOWERS OPERATING COSTS *66%*

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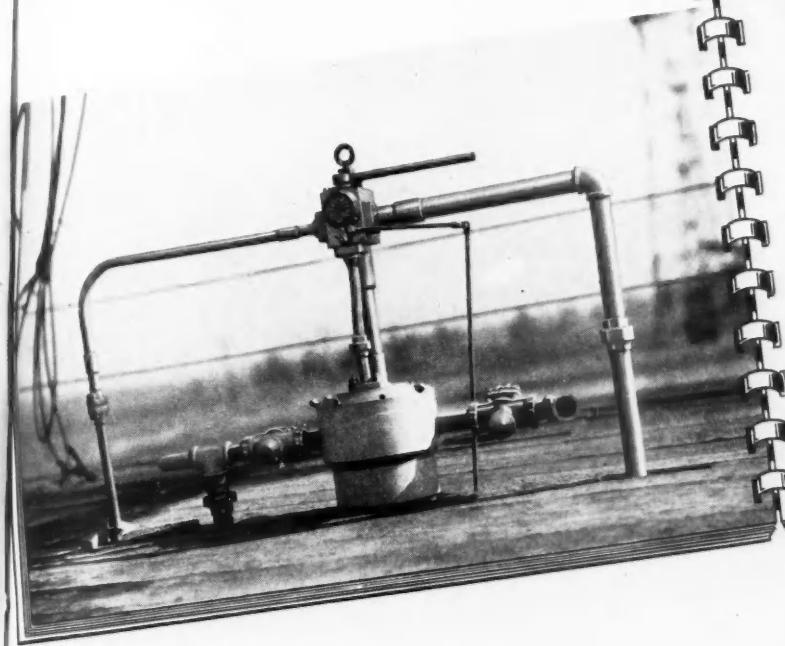
CASE HISTORY

Well No. 26

DEPTH 4710'

DOMINGUEZ FIELD, CALIFORNIA



CASE HISTORY

Comparative 4-Year Operating Costs of Two Wells on Same Lease

The detailed operating costs kept on two Dominguez wells over a period of four years (see below), dramatically reflect the savings achieved by Free Pumping. As the chart and figures show, the big difference in operating cost of the two wells is in pump pulling. Total 4-year pulling cost for the rod pump well was $871; for the Free Pump well only $37.

BREAKDOWN OF OPERATING COSTS

	Well No. 26 Free Pump (51 months)	Well No. 52 Rod Pump (50 months)	Well No. 52* Free Pump (7 months)
Depth	4710 ft.	4228 ft.	4228 ft.
Pump Repair Cost (cost/bbl.)	.58c	.53c	.00c
Pump Pulling Cost (cost/bbl.)	.05c	1.30c	.00c
Total Cost (cost/bbl.)	.63c	1.83c	.00c

***The second half of the story** is even more surprising. It starts with the conversion of Well 52, with which Well 26 is compared, to Free Pumping. In seven months since the conversion was made, no expense has been incurred for repairs or pump pulling.

The performance of *Free Pumping* recorded here is not an isolated instance. *Free Pumping* consistently reduces operating costs because it eliminates the high cost of pump pulling and downtime losses. There is no waiting for equipment. No long delays due to weather or road conditions. One man alone can change a bottom hole *Free Pump*.

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treating a similar type problem.

GAS CAP AND MATERIAL RECOVERY ASSUMPTIONS:

1. The reservoir abandonment pressure will be 300 pounds per square inch absolute. This pressure will not occur during the cycling-pressure maintenance period; however, it will be considered the "end point" of the formation "blow down" period after completion of the cycling-pressure maintenance project.

2. Recoveries from the gas cap by natural depletion to 300 psia will be 71.89 percent of the condensate, 92.16 percent of the butanes, 93.32 percent of propane and 94.42 percent of the dry gas fraction.

3. The plant retention factor for the various products from the gas cap gas would be propane 45 percent, butanes 91.46 percent and 100 percent for condensate.

4. That 70 percent of the reservoir gas cap gas would be displaced by the injected dry gas. In addition, retrograde condensation would occur in the remaining 30 percent during the "blow down" period.

5. The gas cap, although not produced since beginning, had fallen somewhat in reservoir pressure due to rim black oil production, thus causing a relatively small amount of retrograde liquid to drop out of the one phase original fluid. It was assumed that this small volume of retrograde liquid would be revaporized, thus recovered in the same proportion as would be the other existing reservoir phase. This feature is indicated by equilibrium computations using "K" values determined from the Cranfield Basal Tuscaloosa sand gas cap gas for this and other relating purposes.

6. That 8 percent of the dry gas produced will be used for plant and field

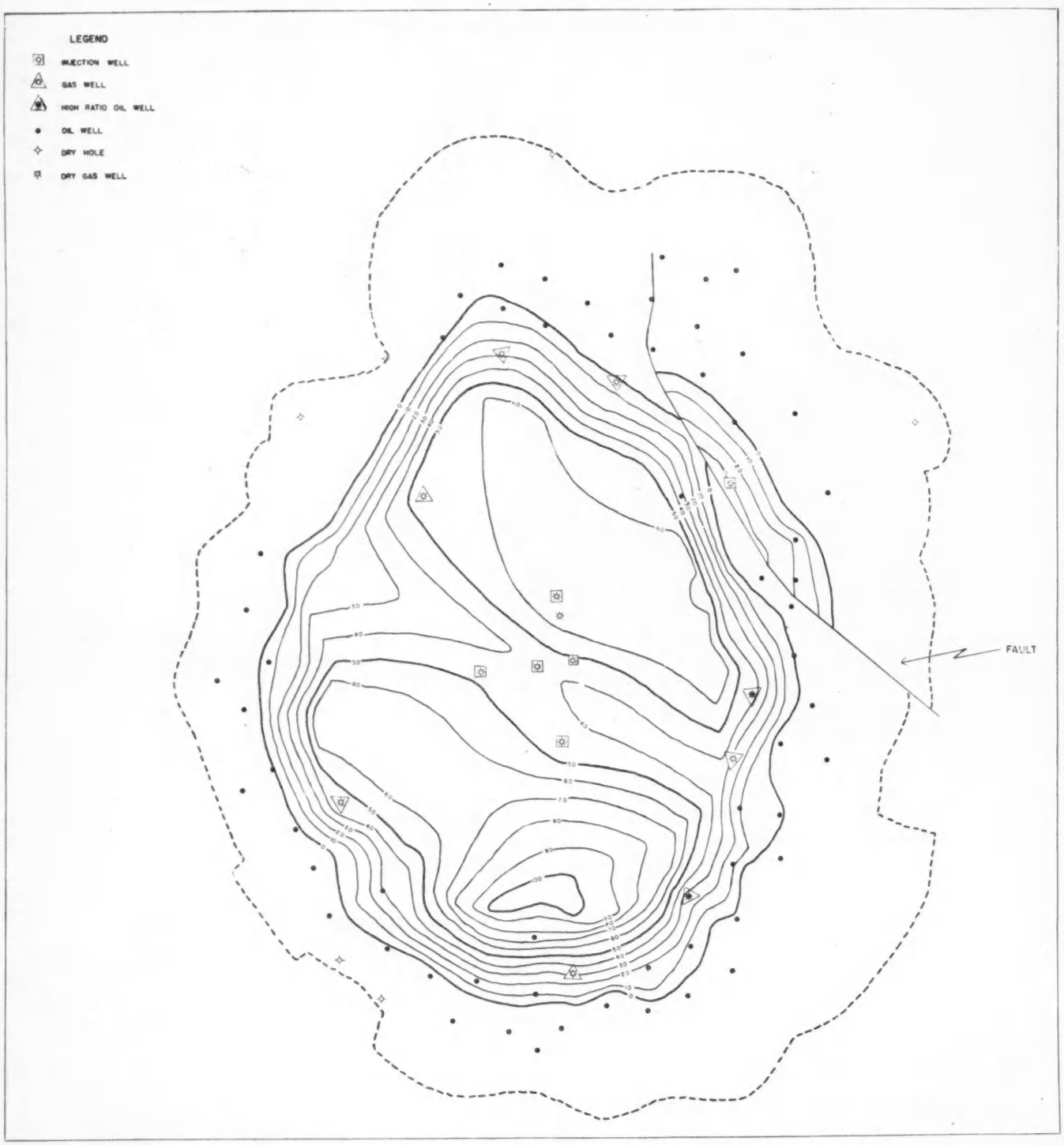

FIGURE 10. Lower member gas isopach.

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operations.

7. Enough dry gas will be returned to the formation so that reservoir pressure will be maintained.

BLACK OIL SAND MATERIAL RECOVERY ASSUMPTIONS:

1. Abandonment pressure will be 300 psia.

2. The plant retention efficiency for the products in the black oil gas will be propane 45 percent, iso-butane 85 percent, normal butane 95 percent and 98 percent for the condensate.

3. That 8 percent of the dry gas produced will be used for plant and field operations.

4. There is no effective water drive in the field.

5. The gas remaining in the voided area will consist of 70 percent dry gas and 30 percent solution gas.

6. That the recoverable oil under full pressure maintenance will be equivalent to 33 percent of the total pore space that has been assumed to be swept by dry gas.

7. That 70 percent of the sand will be swept by dry gas.

8. During the "blow down" stage of production 30 percent of the black oil that was by-passed due to sweep efficiency will be recovered.

The recovery factors of tank oil from the Basal Tuscaloosa black oil sand are given in Table 4.

PALUXY FORMATION ASSUMPTIONS:

1. The reservoir abandonment pressure will be 1000 psia (Increased abandonment pressure over Basal Tuscaloosa formation is due to the economics of

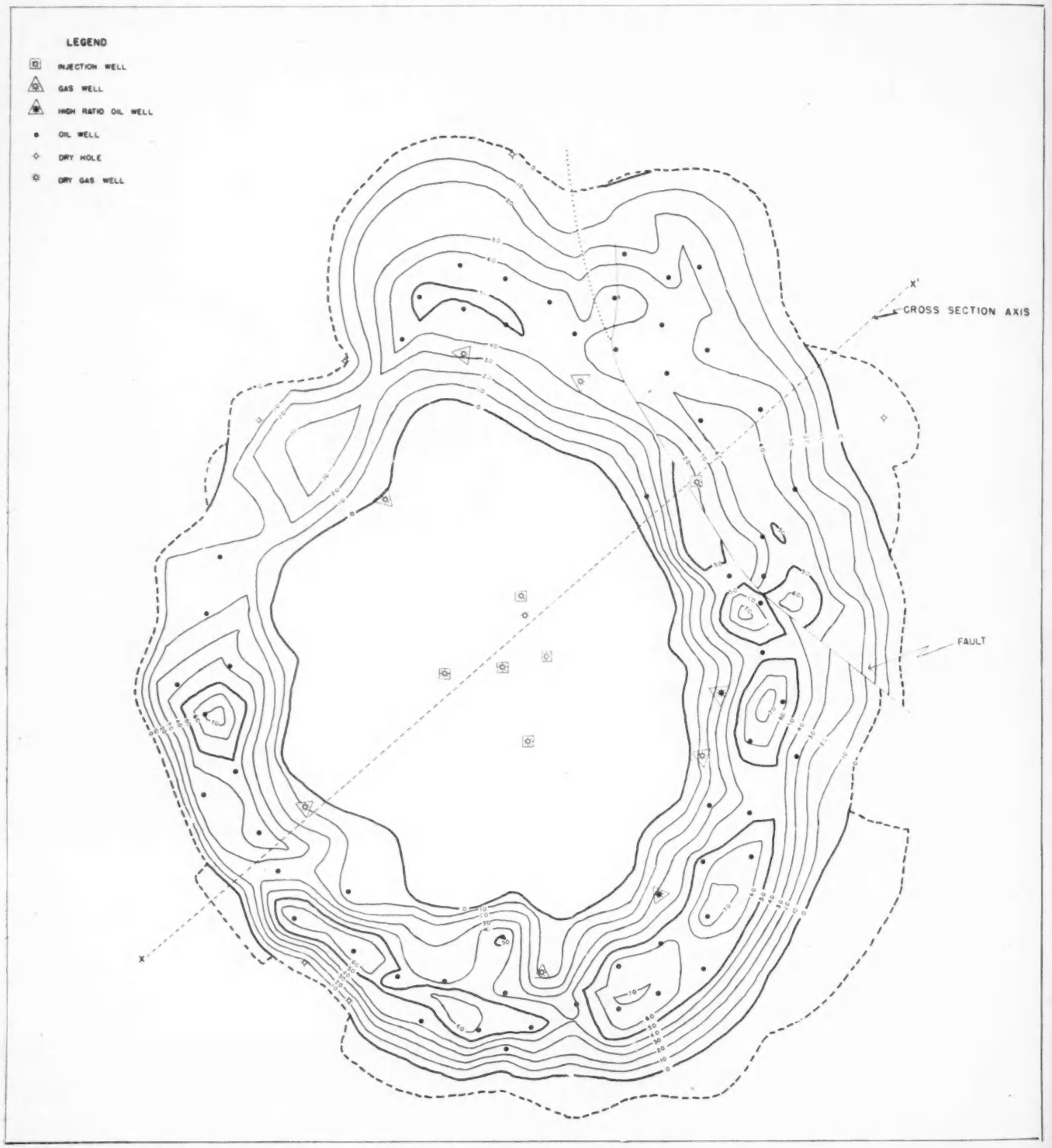

FIGURE 11. Lower member oil isopach.

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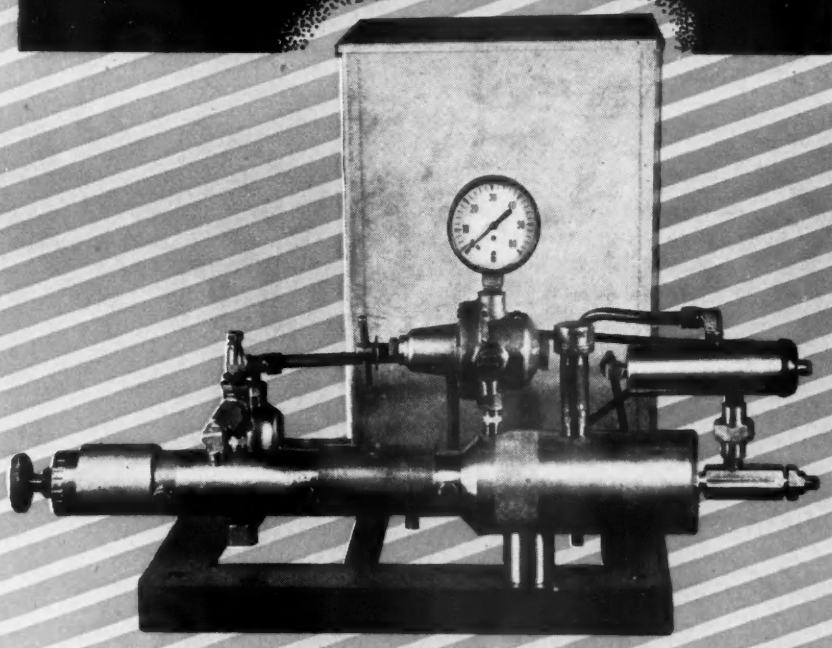

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producing an absolute dry gas relative to a somewhat wet gas, the cored relatively low permeability of the sand and the fact the Paluxy sand is approximately 1500 feet deeper than the Basal Tuscaloosa formation).

2. That 8 percent of the gas will be used for plant and field operations.

The sand has no water drive in the Cranfield field.

Recovery factors for the Paluxy formation are indicated in Table 5.

DEFINITION OF PRODUCTS IN UNITIZATION AGREEMENT

TANK OIL consists of the residual atmospheric tank liquid resulting from stage separation of the black oil formation fluid.

CONDENSATE consists of the recoverable iso-pentane plus fraction in both the gas cap formation fluid and in the liberated solution gas from the black oil fluid.

BUTANE consists of the recoverable iso-butane and normal butane fractions in both the gas cap and black oil formation fluids except those normally present in the tank oil.

PROPANE consists of the propane fraction recoverable as such in both the gas cap and black oil formation fluids.

DRY GAS consists of the non-liquefiable fractions of the well effluents from both gas cap and black oil zones of the reservoir.

ACKNOWLEDGMENT

The author is indebted to Messrs. E. M. Kipp and A. L. Vitter for their invaluable advice and criticisms relating to the organization, etc., of the subject matter.

Acknowledgment is also made to the Cranfield Unit Operators, Placid Oil Company, Gulf Refining Company and The California Company, for permission to publish this paper.

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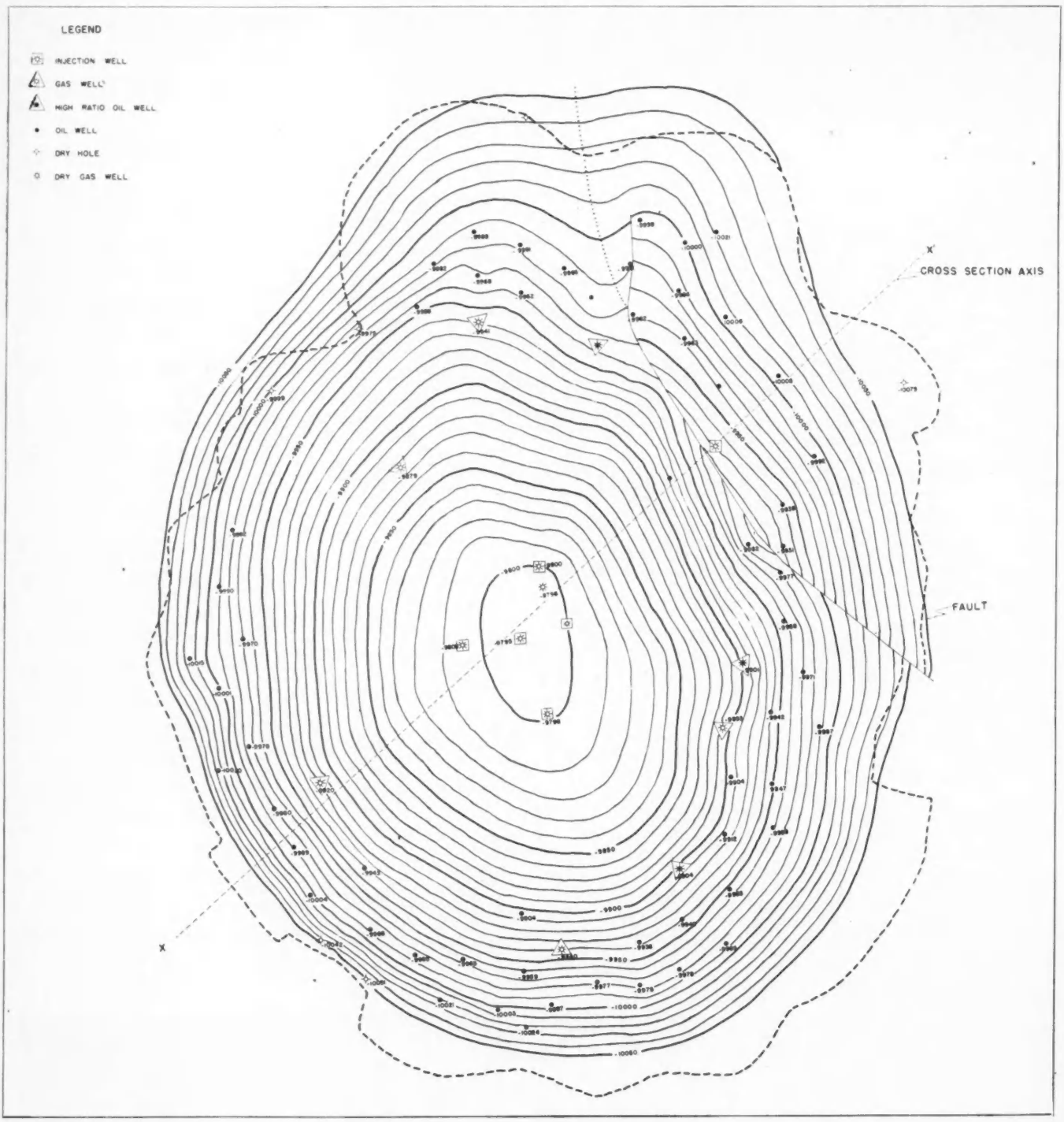

FIGURE 12. Basal Tuscaloosa sand structure map.

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Stream Analyses Locate Oil Field Pollution Sources

By OGDEN S. JONES

Chief Geologist, Kansas State Board of Health
Division of Sanitation, Oil Field Section

SOUTHEASTERN Kansas has a limited supply of ground water and municipalities are forced to depend upon surface supplies either directly from the stream, or impounded. It is, therefore, essential that in these streams chlorides and industrial wastes be held at a minimum.

The two principal streams in southeastern Kansas are the Neosho and the Verdigris Rivers. Both streams embrace in their drainage basins approximately two-thirds of the shallow oil fields of that area. In these old fields are several thousand producing oil wells and one would suppose these two streams would carry a heavy salt load. However, it is an exceptional chloride reading for either of these streams to show over 200 parts per million in chlorides. Normally, the chloride content is below 100 parts per million. The reason for these streams maintaining low chloride loads is due, primarily, to the relatively small quantities of brine produced with the oil as compared to the fields in the western part of the state. Also, considerable produced brine is used in water flooding as there are many secondary recovery projects in operation. Another factor is that the static water level of the mineralized water is considerably below the fresh water beds and, unless disturbed by repressuring in an area of inadequately plugged wells, this water seldom reaches the surface. The water-flood operator has, of necessity, had to repair some of the old, abandoned wells in order to hold the flood on the sand face, thereby saving water and maintaining the pressure for the water drive.

THE OIL FIELD SECTION of the Division of Sanitation of the Kansas State Board of Health was set up in 1935 and charged by statute to protect the fresh waters of the state from oil-field pollution. Prior to 1935 salt water produced with oil in Kansas posed a serious problem to producer and landowner since little thought was given to adequate brine disposal. As a consequence, fresh water wells became brine contaminated and fish and aquatic life in surface streams suffered from salt water. Oil companies were harassed with pollution litigation. The department sponsored the returning of salt water to deep, sub-surface formations, a practice which is now being followed by oil companies and recommended for all oil areas confronted with similar problems.

Table I gives weekly chloride readings on the Neosho and Verdigris Rivers for the first six months of 1949. It can be presumed that water conservation measures are fairly well established in these watersheds, otherwise these two streams would conceivably carry higher chloride loads. Drought years are critical due to a constant chloride input with a decreased fresh water input. The fresh water brine ratio must be observed and checked.

For their own protection several oil companies have seen fit to run stream samples. It can be assumed that such a practice will show a particular company just who is responsible for the brine pollution and, if the pollution is checked to that company lease, brine control can be put into effect immediately. If, on the other hand, the sampling and analyses point to an adjacent lease the company with the stream sampling record is in a much stronger position as far as litigation is concerned.

Howard Stoltenberg, Chief Chemist

TABLE 1
Sources of Oil Field Pollution Located by Stream Analyses

NEOSHO RIVER At Chanute		VERDIGRIS RIVER At Benedict	
DATE	Chloride	DATE	Chloride
1949		1949	
Jan. 5	70	Jan. 5	210
Jan. 20	50	Jan. 20	80
Feb. 2	30	Feb. 2	80
Feb. 23	60	Feb. 23	60
Feb. 26	7		
March 2	25	March 2	50
March 9	30	March 9	100
March 18	40	March 18	80
March 23	40	March 23	70
March 24	20	March 24	50
April 7	50	April 7	70
April 14	30	April 14	60
April 20	60	April 20	100
April 27	30	April 27	50
May 5	30	May 5	60
May 12	30	May 12	110
May 19	40	May 19	50
May 26	30	May 26	60
June 2	30	June 2	100
June 8	40	June 8	50
June 16	30	June 16	80

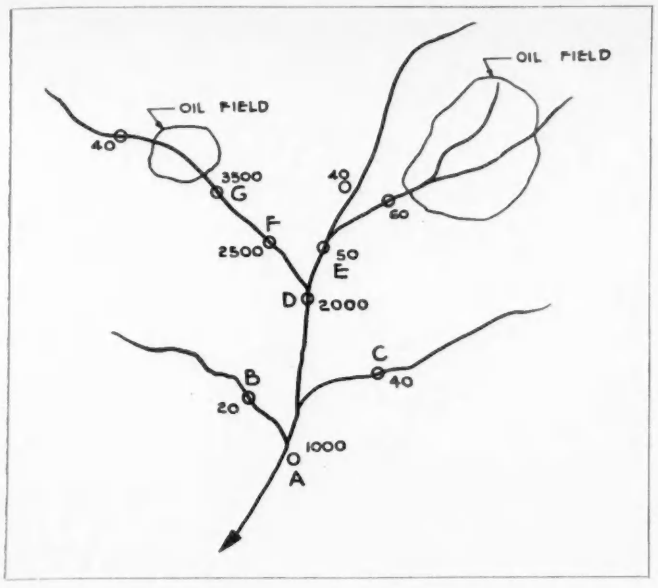

FIGURE 1. Locating the oil field responsible for pollution. Note O marks the sampling point. Figures denote chlorides in parts per million.

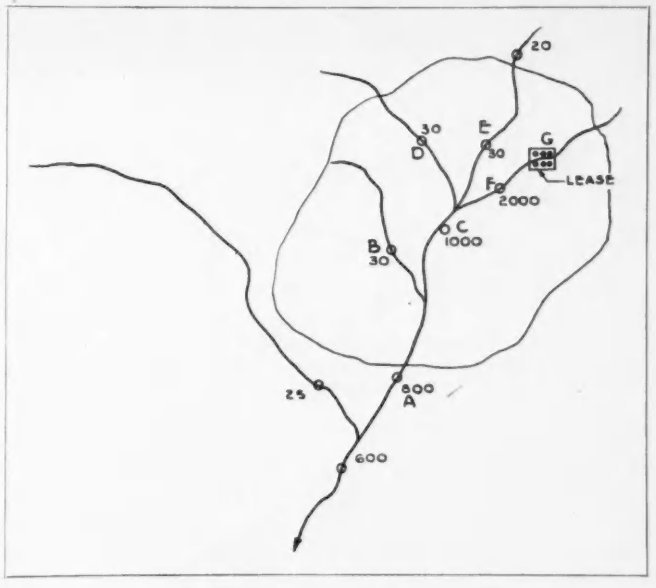

FIGURE 2. Locating the lease responsible for the pollution.

for the Division of Sanitation of the Kansas State Board of Health, has prepared the following procedure to follow in simple chloride titrations out in the field. The equipment necessary can be placed in a small kit suitable to carry in a car.

Field Determination of Chloride

Since all oil field brines contain large quantities of chloride, principally in the form of sodium chloride, or common salt, perhaps the simplest method of tracing oil field pollution in the field is the chemical determination of chloride.

The determination is based on the quantitative reaction between silver nitrate and a chloride; for example, sodium chloride.

$$AgNO_3 + NaCl = AgCl + NaNO_3$$

Insoluble silver chloride (a white precipitate) is produced as long as any chloride remains in the solution. If a measure can be made of the quantity of silver nitrate necessary to completely react with the chloride, the concentration of chloride can be readily calculated from the above equation.

In the determination, the quantity of silver nitrate is measured by using a standard solution of that substance of definite, known strength. In order to avoid adding an excess of silver nitrate, the analysis is carried on in the presence of potassium chromate indicator.

Silver chloride will be preferentially precipitated due to its extreme insolubility. When all chloride has disappeared from solution, silver chromate, a red precipitate, will form. The first permanent appearance of this red color marks the end of the determination.

Sulfides, if present, interfere because of the early appearance of black silver sulfide. However, the characteristic odor of hydrogen sulfide is easily noticeable in water and, by boiling the measured sample a few minutes, sulfides can be reduced to the point where they will no longer seriously interfere.

Recommended Apparatus and Reagents for the Determination

1. 25 cc burette with suitable support
1 250 cc glazed porcelain casserole
2 Glass stirring rods
2 50 cc volumetric pipettes
1 25 cc volumetric pipette
1 10 cc measuring pipette, graduated in tenths of cc
1 50 cc graduated cylinder
1 Bottle of potassium chromate indicator (50 gm potassium chromate per liter of solution.) (The bottle should be equipped with a rubber bulb and pipette marked at 1cc.)
1 Bottle of standard silver nitrate solution of such strength that 1cc = 5.0 mg. chloride.

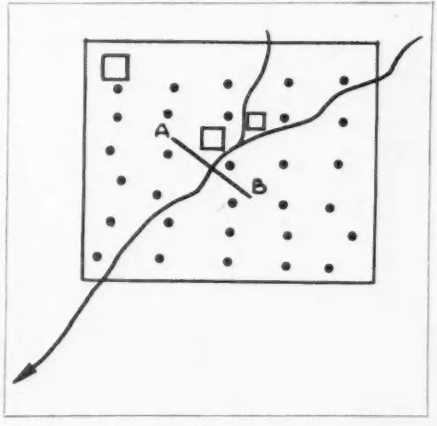

FIGURE 3. Locating the salt water responsible for the pollution. Section A-B line of auger tests for water sampling down drainage from the ponds.

1 Bottle of distilled water for making dilutions.

Procedure for the Analysis

1. Fill the burette with standard silver nitrate solution and drain to the zero mark; make sure no air bubbles are trapped in the stopcock or delivery tip.
2. Pipette 50 cc of the sample into a porcelain casserole.
3. Add 1 cc of potassium chromate indicator.
4. Add the silver nitrate solution slowly, with constant stirring, until the first permanent reddish color appears. Record cc of silver nitrate used.
5. If more than 25 cc of silver nitrate are required, repeat the procedure using a smaller sample diluted to 50 cc with distilled water.

Calculations:

The recommended silver nitrate solution for oil field work is of such strength that 1 cc is equivalent to 5.0 milligrams of chloride.

(cc of silver nitrate used) × 5.0 = milligrams of chloride in the sample used.

$$\frac{(\text{cc of silver nitrate used}) \times 5.0 \times 1000}{\text{cc of sample}}$$

= milligrams of chloride in 1 liter of sample or essentially parts per million (ppm)

To express in terms of sodium chloride:

$$\text{ppm chloride} \times \frac{58.5}{35.5} = \text{ppm as sodium chloride.}$$

Figure 1, for locating the oil field responsible for the pollution, shows a drainage system with two oil fields located in it. Point A shows the first sampling point and 1000 parts per mil-

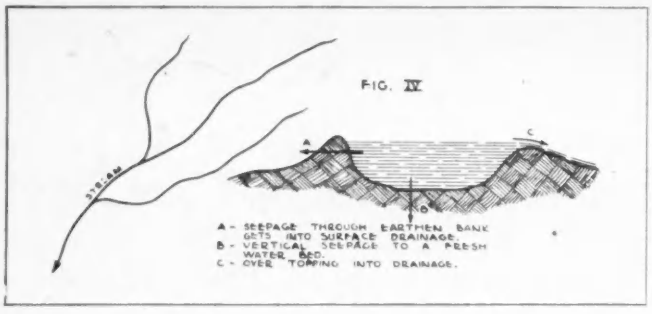
FIG. IV
A - SEEPAGE THROUGH EARTHEN BANK GETS INTO SURFACE DRAINAGE.
B - VERTICAL SEEPAGE TO A FRESH WATER BED.
C - OVER TOPPING INTO DRAINAGE.

FIGURE 4. A—Seepage through earthen bank gets into surface drainage. B—Vertical seepage to a fresh water bed. C—Over topping into drainage.

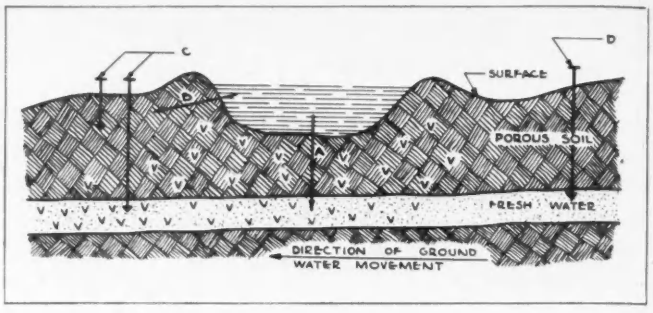

FIGURE 5. A—Vertical seepage. B—Horizontal seepage. C—Test holes put down for water samplings. V—Salt water.

lion in chlorides. Points B and C are two tributary streams showing 20 and 40 parts per million of chlorides, respectively, and are consequently eliminated as sources of brine pollution. Point D is at the junction of two streams each of which embrace an oil field. The chloride reading at this point shows 2000 parts per million of chlorides. Point E shows 50 parts per million of chlorides and a field located on that stream is thereby ruled out as the source of pollution. Point F shows 2500 parts per million of chlorides. Point G shows 3500 parts per million of chlorides.

Thus, by a series of sampling we have traced the reported pollution to this one field.

It should be noted that the chloride concentration diminishes the farther away the sampling points are from the point of pollution. This is accounted for by the fact that tributary drainage dilutes the stream.

Locating the Lease

Figure 2 is for locating the lease responsible for the pollution.

Having located the field, we carry the process further, and by a series of sampling and analyses we endeavor to locate the particular lease or leases which are allowing large amounts of salt water to enter the drainage.

Point A shows 800 parts per million of chlorides on a main stream as it leaves the oil field. Point B on a tributary drainage shows only 30 parts per million of chlorides and is, thereby, eliminated as carrying any pollution on that portion of the field. Point C shows 1000 parts per million of chlorides and indicates that points D, E or G must be checked to locate the stream carrying the pollution load. Points D and E show 30 parts per million of chlorides each, thus the leases on those two streams are eliminated as contributing to the pollution. Point F shows 2000 parts per million of chlorides which definitely proves that Lease G on this stream is being operated in such a manner as to allow the escape of the mineralized water into the drainage.

It should be borne in mind that the chloride figures given in these two illustrations are arbitrary figures and are much lower in chloride content than is usually found in actual practice. Also, being arbitrary figures, we have made no attempt to correlate the readings between these two figures but have used them only to bring out the steps in our procedure.

Figure 3 is for locating the actual source of the pollution from the lease in Figure 2.

The squares denote brine disposal ponds and it will be noted that two of these ponds are located in close proximity to drainage. Providing these ponds are not over-topping, or leaking through the embankment, which would show visible pollution in each case, it is sometimes necessary to put down a series of auger holes between A and B. This series of auger holes is located downstream from the ponds and are put down deep enough to catch any water which has leaked out of the bottom of the pond and joined the underground water movement down-drainage.

Water samples are collected from these auger holes and analyzed for chloride content. Even though there is no visible surface drainage, or seepage, or over-topping from the ponds, the presence of high chloride readings from the samples collected from auger holes is irrefutable evidence that the pond is leaking and that the mineralized water is either getting into surface drainage, or the first shallow groundwater.

Figure 4 is a cross-section of a brine disposal pond.

On the assumption that all ponds leak to some extent, this figure illustrates the principal points of leakage.

A shows the seepage through the earthen embankment and which will, eventually, reach the stream as illustrated. The first leak often occurs at the contact of the earthen embankment and the original ground. B shows vertical seepage from the bottom of the pond. C shows over-topping of the pond and how it goes directly into some drainage.

Figure 5 is a cross section of a brine pond located in porous soil.

The pond illustrated shows the attempt to store salt water in a pond constructed in a porous soil with no impervious strata between the bottom of the pond and the first fresh water horizon. It has been found in practice that this type of pond can always be found to be a direct source of ground water pollution.

Figure A shows the vertical seepage into the fresh water bed. Figure B shows the infiltration through the embankment. Figure C shows the location of two auger test holes put down for sampling purposes. The shallower hole will pick up a representative sample of the salt water seeping through the embankment; and the deeper hole, contacting the fresh water bed, will prove conclusively that this pond is responsible for the contamination.

Figure D is another auger hole contacting the fresh water bed. It is located upstream from the pond which, if relatively low in chlorides as compared with the auger tests down-stream from the pond, is conclusive proof that this pond is contaminating the water bed illustrated.

Conclusion

It is hoped that this article will be of some benefit to oil companies and that the use of the described procedure not only will check their own operations, but also will strengthen their position if litigation should be involved. A record of stream analyses, plus a record of the salt content of fresh water in the vicinity of oil operations, are valuable to the operator. It is a wise practice to establish the above facts before operations start in a new area. It is unfair to the operator to be blamed for a salt condition in a stream if, before the advent of drilling, this stream normally carried a load of formation salt.

Making sure that oil operations are not a hazard to the fresh water supplies is a contribution the oil industry can make, and in a large part is making, to fresh water conservation. Adverse comment to the industry can be eliminated for good will by care in the disposal of salt water produced with the oil.

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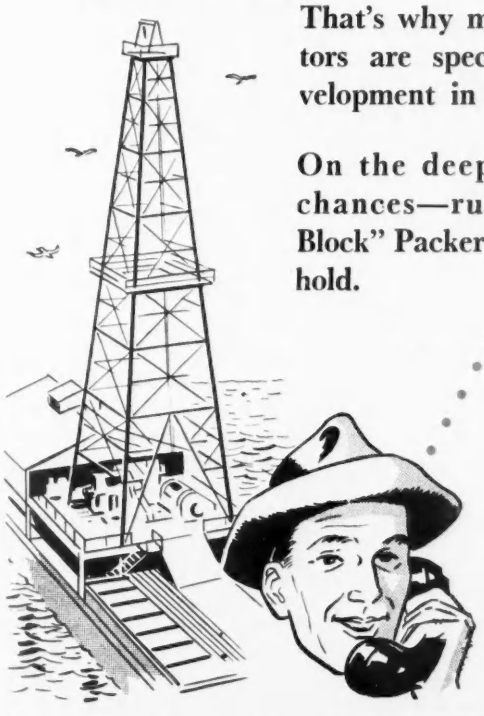

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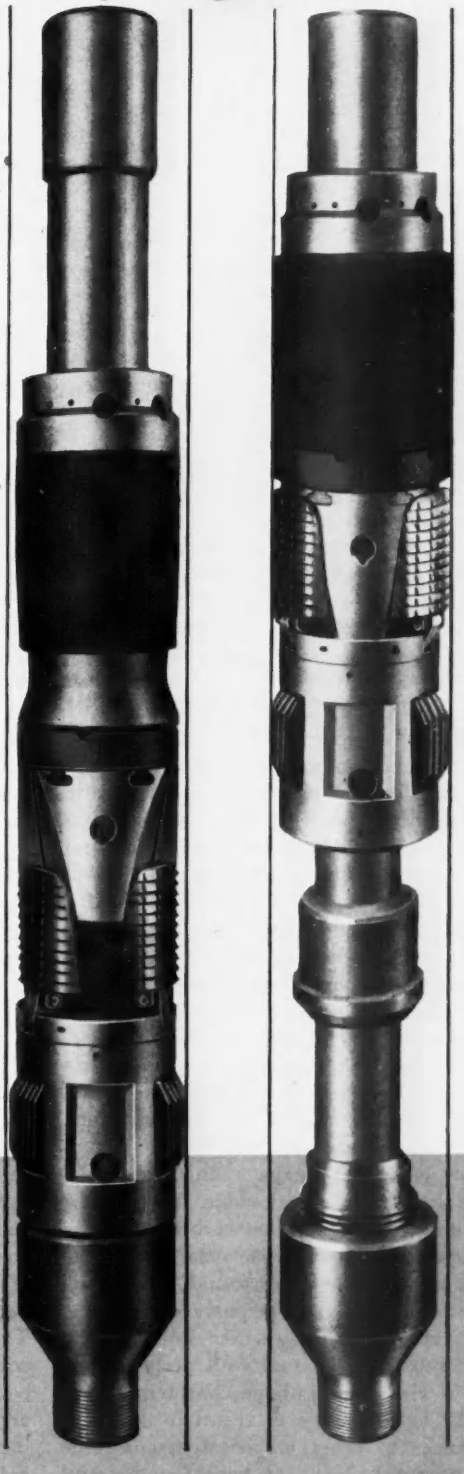

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Injectivity Indices

Their Prediction and Determination

By N. VAN WINGEN
Vice President, Petroleum Technologists, Inc.

THE availability of adequate injectivity index data is essential in the planning stage of a fluid injection project in order to ascertain whether individual well injection volumes, as indicated by reservoir analysis studies, can be handled at economically feasible injection pressures. Pressure information is also desirable in order to properly design compressor plant facilities.

Once a project is in operation it is desirable to follow closely injectivity index trends of the wells. When such data are used in conjunction with other pertinent information they will give an early indication of plugging of the sand face, thus making it possible to perform remedial work at a time when it is most likely to be successful. Injectivity index data will also indicate readily whether or not the entire sand section or only a portion thereof is taking fluid.

Injectivity Index Predictions

Radial or spherical flow formulas can be used to compute injectivity indices if certain basic reservoir characteristic data are known. One of the prime difficulties involved in such a procedure, however, is the establishment of reliable effective permeability data. This difficulty can be overcome to a certain extent by utilizing specific productivity indices as observed when the wells were producing, for the purpose of analytically deriving therefrom effective permeabilities. At best, however, this entire procedure is tedious and time consuming and because of other assumptions which have to be made, such as the determination of the drainage radius, the final result is often questionable. As a matter of fact, for a number of high-pressure gas cap injection projects the above analytical procedure was found to give results which were obviously out of line, a fact which was further substantiated by subsequent actual well performance.

In view of the above considerations it may be necessary to resort in some instances to other empirical means. One procedure which has been found useful in a number of projects where existing wells were to be used for injection purposes involves the application of a mass productivity index. In this measure of well productivity per pounds per square inch drawdown, production is expressed in terms of pounds of hydrocarbon material produced instead of the conventional barrels of oil per thousand cubic feet of gas.

THIS ARTICLE is substantially a paper presented at the recent secondary recovery symposium of the Mid-Continent district standing sub-committee on secondary recovery methods, topical committee on production technology, API Division of Production, held in Oklahoma City.

In applying this method it is assumed that the ability of a well to take gas as expressed in terms of pounds is equivalent to the prior ability to produce hydrocarbons, the latter figure to be corrected, however, to compensate for respective differences in viscosity and compressibility and for the fact that the average bottom-hole injection temperature is generally less than the producing temperature. Because of these latter considerations it has been found in several gas reservoirs that the initial injectivity mass indices were approximately 1½ times greater than the immediately preceding producing mass indices.

The following specific field data is of interest to illustrate the relative degree of accuracy of the above outlined procedure. For field "A" it had been computed that it should be possible to inject 3000 MCF per day in well No. 1 at a surface pressure of 3200 pounds per square inch. Subsequent actual performance indicated that this amount of gas could be injected initially at a pressure of 3000 pounds per square inch or 6.6 percent less than had been estimated. This error is of course not entirely attributable to inaccuracies involved in the computation of the injectivity index as error could have resulted also from tubing friction and gas column weight calculations. For field "B", gas was to be injected in four wells. Preliminary tubing head injection pressure estimates for the various wells at the injection rates as shown compared to subsequent actual performance data as follows:

Well No.	Injection Rate MCF/D	Tubing Head Injection Pressure PSI Calculated	Observed
1	5000	3408	3400
2	5000	3470	3450
3	22500	3510	3450
4	4600	3170	3200

Injectivity Index Determination

Injectivity indices can be determined accurately by measuring bottom-hole pressures at various injection rates by means of a depth pressure recorder. In some instances it may be hazardous or otherwise undesirable to run a pressure bomb, as when gas is being injected in an annular space in a multiple zone well or in a single zone well when injection rates and surface pressures are extremely high. For the latter case if injection is taking place through the tubing it would theoretically be most convenient to compute the bottom-hole pressure for any given injection rate by adding the gas column weight to the observed casing pressure. Experience indicates that such a procedure is subject to a substantial potential error due to the fact that an unknown amount of liquid may be standing in the annulus. Furthermore, the average gravity of the annular space gas is generally unknown as it is usually a mixture of wet and dry injection gas. Thus it has been found to be more expedient to compute the bottom-hole pressure using injection string data even though this introduces the added problem of kinetic friction. Such an equation also has the added advantage that it can be applied to annular space injection operations. Due to friction there is a tendency for the pressure to decrease in the direction of flow. Due to the static weight of the gas column there is a tendency for the pressure to increase with increasing depth in the well. Thus, it is evident that for the case of downward flow (injection) the two effects are compensating so that the terminal pressure may be either greater

or less than the initial surface tubing pressure.

One expression which can be used for the purpose of evaluating gas flow friction is the Weymouth equation. It is to be borne in mind, however, that this expression was derived to apply principally to problems relating to the high volume and relatively low pressure transmission of gas. Actually, when dealing with high pressure injection well problems, the density of the gas is such that its behavior can probably be considered to nearly simulate that of a liquid, in which event it would be preferable to use an empirical liquid flow equation such as Weisbach's, rather than the Weymouth formula. In order to ascertain which of these two expressions would be more nearly applicable several depth pressure and temperature runs were made at various injection rates in two wells in field "A". From an interpretation of these data an empirical relationship was established between rates of injection and the pressure drop due to friction. It is felt that these data are reasonably reliable as they are based upon direct pressure measurements except for the computation of the gas column weight which, under the conditions encountered, could be evaluated accurately. The rate-friction relationship determined in a manner as discussed is shown in Figure 1 together with similar data as computed on the basis of Weymouth's and Weisbach's equations respectively. It is to be noted that the observed friction values are considerably less than those indicated by the Weymouth formula but greater than those computed by the Weisbach equation. With regard to the latter expression it is to be noted that for the curve as shown, a friction factor (f) was taken from published data for pipe most nearly comparable to the tubing used in the well. Such a figure would not be sufficiently high to be representative of over-all flow string conditions as the added resistance offered by the couplings should also be taken into consideration. It is apparent, however, that the liquid flow formula and the empirical curve can be made to agree provided a relatively minor adjustment of the friction factor used were to be made. Friction factors computed on the basis of such an agreement are shown as a function of Reynolds number in Figure 2. It is believed that these data should be generally applicable to any string of 2½-inch tubing.

In view of the above considerations it was concluded that an equation to compute bottom-hole pressure from surface tubing pressure could most accurately be derived by combining an expression for column weight with the Weisbach equation. Such an expression can be derived as follows:

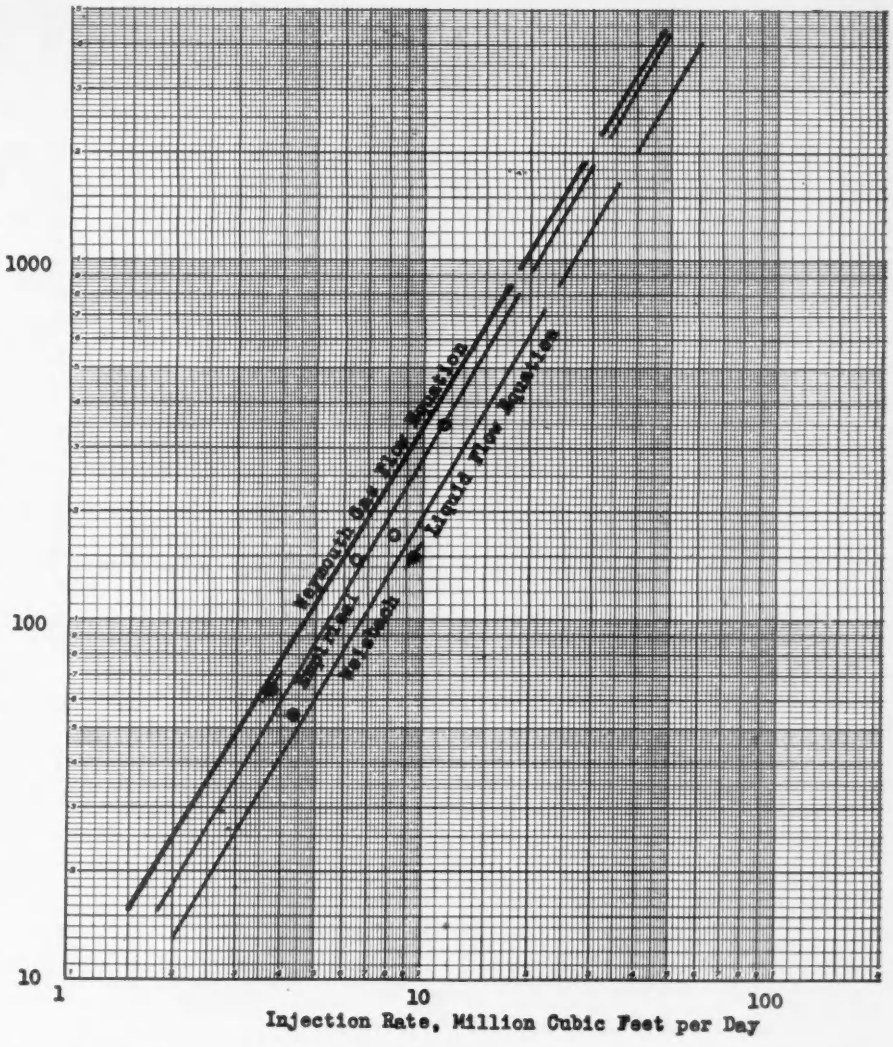

Figure 1. Friction drop vs. rate of gas injection. Injection through 2½-inch tubing. Gas gravity 0.683. Reservoir pressure ± 3400 psi at 8500 feet subsurface. Surface injection temperature ± 120° F.

Static weight of the flowing gas column (See nomenclature at end of report):

$$Pv = ZRT$$

$$w = \frac{1}{v} = \frac{P}{ZRT}$$

$$dP = wdx = \frac{P}{ZRT}\,dx$$

Therefore,

$$\frac{dP}{P} = \frac{dx}{ZRT} \text{ or for gas of spec. grav. s}$$

$$\frac{dP}{dx} = \frac{sP}{ZRT} \text{ or letting } \frac{s}{ZRT} = c$$

$$(1) \qquad \frac{dP}{dx} = cP$$

Weisbach's equation states that

$$h_L = \frac{fL}{D} \cdot \frac{V^2}{2g} = \frac{dP}{w}$$

$$V^2 = \frac{W^2}{A^2w^2}$$

$$dP = \frac{W^2}{A^2D^2g} \cdot \frac{fdx}{w} = \frac{af}{w} \cdot dx \text{ where } a = \frac{W^2}{A^2D^2g}$$

$$w = \frac{1}{v} = \frac{1}{v_1} \cdot \frac{(P)}{(P_1)}^{\frac{1}{n}}$$

As a value of n = 1 has been found to be generally representative for natural gas flow pressures,

$$w = \frac{P}{v_1P_1}$$

Hence,

$$\frac{dP}{dx} = \frac{afv_1P_1}{P} \text{ if we let } afv_1P_1 = b$$

$$(2) \qquad \frac{dP}{dx} = \frac{b}{P}$$

Therefore, $\int Pdp = b\int dx$

or $P^2B - P^2T = 2bL$

The actual pressure gradiant in the flow string is thus obtained by combining equations (1) and (2) or:

$$(3) \qquad \frac{dP}{dx} = cP - \frac{b}{P} \text{ or}$$

$$PdP = (cP^2 - b)dx$$

$$\int_t^P \frac{PdP}{cP^2-b} = \int_o^L dx$$

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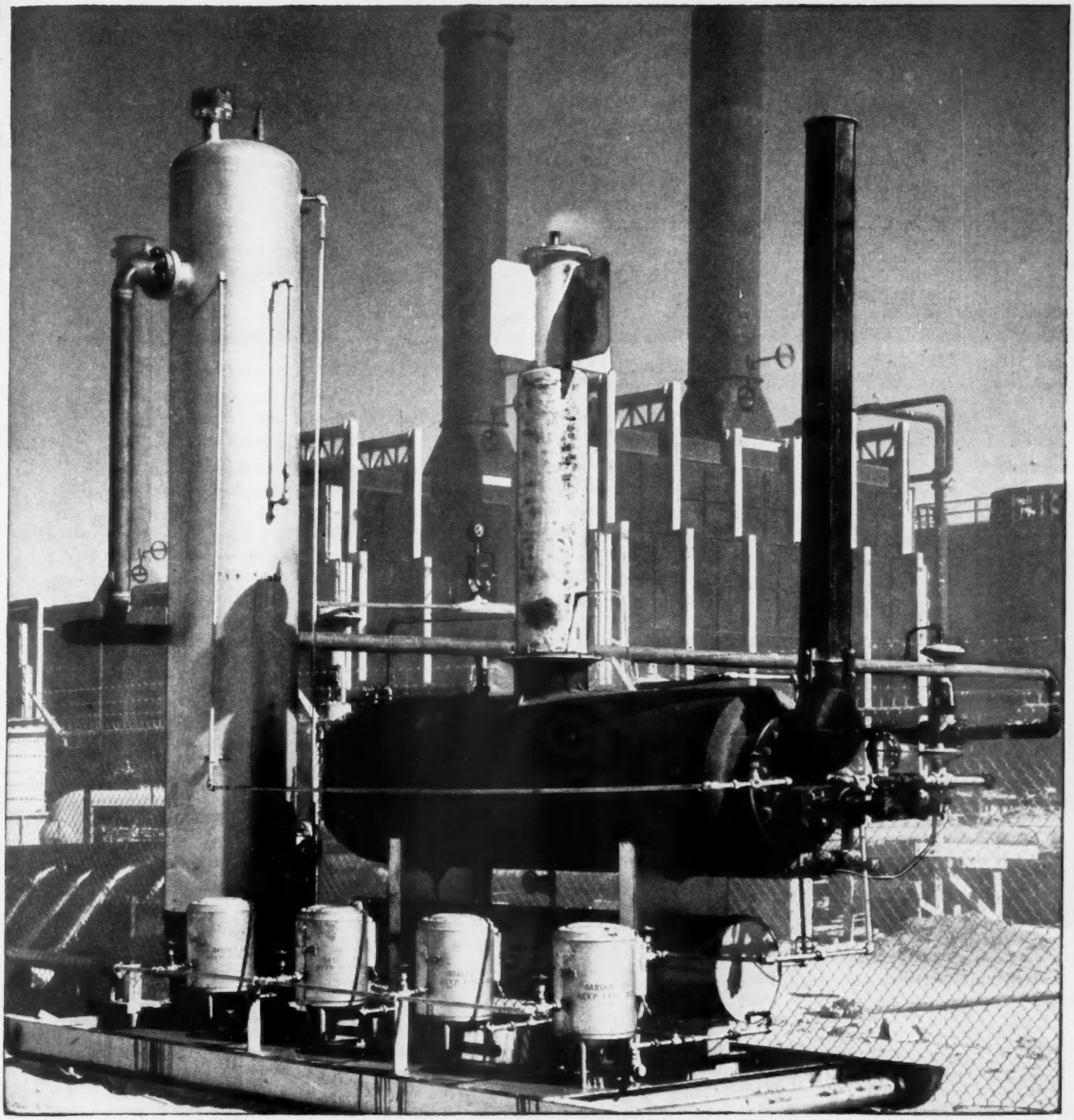

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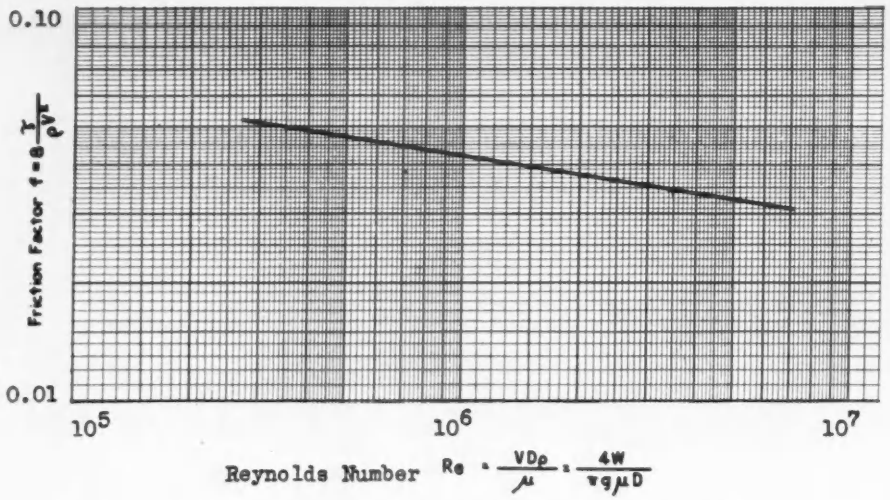


Figure 2. Tentative relation of friction factor and Reynolds number.

integrating:

$$L = \frac{1}{2c} \log_e \left(P^2 - \frac{b}{c} \right)$$

If we let $2cL = d$

$$e^d = P^2B - \frac{b}{c} / P^2T - \frac{b}{c}$$

$$\text{or } P^2B = e^d P^2T + \frac{b}{c}(1 - e^d) \qquad (4)$$

$$\text{and } P^2T = \frac{P^2B}{e^d} - \frac{b}{c}\left(1 - \frac{1}{e^d}\right)$$

The constants appearing in equation (4) are directly evaluable from basic data with the exception of "C". To obtain this latter figure, estimate of the temperature and the compressibility factor for average flow string conditions of pressure and temperature have to be made. Hence, for rigorous solution this introduces the element of iteration or trial and error solution. However, it has been noted from the empirical data, that a fairly definite relation appears to exist between the temperature increment with depth and the rate at which gas is being injected. This relations appears to be a function to some extent also of the absolute value of the initial or well head temperature. Temperature increment data for field "A" are presented graphically in Figure 3.

Regarding the compressibility factor it is to be noted that near 3000 pounds per square inch this factor changes only by 0.01 as the pressure changes plus or minus 300 pounds per square inch. As the average pressure can be determined easily within such a limit of accuracy the process of trial and error solution should not be cumbersome.

All factors necessary to establish the Reynolds number are available from direct measurements with the exception of the gas viscosity which is a function of the average pressure and temperature. Similiarly to the compressibility factor, however, the viscosity is not very sensitive to the absolute value of the pressure and temperature within the range found in the average injection well, the increase being only eight micropoises when the pressure changes from 3000 to 3500 pounds per square inch and 13 micropoises when the temperature changes from 100 to 160° F. Hence, a viscosity value commensurate in accuracy with that of the other variable involved should be attainable.

It is conceded that the approach as here presented is not strictly rigorous because of the inherent though minor element of trial and error manipulation. However, for engineering calculations the equations have already been found to be extremely useful and time saving. In order to assure proper accuracy it is of course desirable in any given field to make initial bottom-hole pressure and temperature determinations by means of instruments at various rates of injection so that graphical presentations corresponding to Figures 2 and 3 can be constructed for the particular field in question and the proper friction factor determined for the flow string in question. When the equations as developed here are utilized on this restricted basis it is felt that the results obtained will be commensurate in accuracy with those of the field measurement of injection rates and gas gravities. Once the initial pressure and temperature runs have been made additional injectivity indices can then be computed without the necessity of making further time consuming field tests. As reservoir conditions change with time, it is evidently desirable occasionally to check by means of instruments runs the continued applicability of Figures 2 and 3.

NOMENCLATURE

a = Constant = W^2/A^2D2g
A = Area of injection string in sq. ft.
b = Constant = afv_1P_1
c = Constant = s/ZRT
d = Constant = ZcL
D = Inside diameter of injection string in ft.
e = Base of the Napierian logarithm = 2.7183.
f = Friction factor—dimensionless
g = Gravitational constant ft/sec²
L = Length of injection string ft.
P = Pressure lbs. per sq. ft. abs.
P_1 = Surface injection pressure lbs. per sq. ft. abs.
P_B = Subsurface injection pressure lbs. per sq. ft. abs.
P_T = Surface injection pressure lbs. per sq. ft. abs.
R = Universal gas constant foot-pounds per pound degree Rankin = 53.33
s = Spec. gravity of gas referred to air
T = Absolute temperature ° Rankin
V = Velocity ft./sc.
v = Specific volume in cu. ft./lb.
v_1 = Specific volume at surface injection pressure
W = Mass rate of flow lbs./sec.
w = Specific gravity of gas lbs./cu. ft.
x = Unit of length of injection string ft.
Z = Compressibility factor, dimensionless
μ = Viscosity of gas lb. sec./ft.²

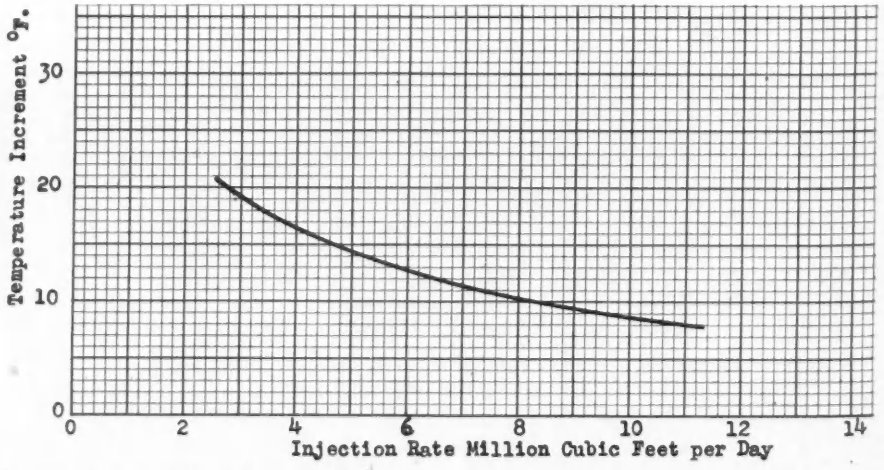


Figure 3. Increment to obtain mean temperature of injection string as related to injection rate. Injection through 8500 feet of 2½-inch tubing. Gas gravity 0.683. Reservoir pressure 3400 psi. Injection temperature 120° F.

TEMBLOR SAND
IN RAISIN CITY FIELD
FRESNO COUNTY, CALIFORNIA

Mud (Gel, Quebracho): R_m = 3.5 ohms at BHT
Bit Size: 7⅝"
Spacings: AM = 10"
AO = 10'
AO' = 19'

This is another in a series of interpreted electrical logs from identified formations and fields which Schlumberger will reproduce in this publication. If you would like to keep this entire series, please write to us on your letterhead and we will be glad to send you a reprint of this log (and preceding logs in this series) with a binder in which you may file subsequent logs as they are published. This series is made possible through the courtesy and cooperation of the oil operators who have released these logs.

7

LOG ANALYSIS

1) Water saturation S

In level A, comparison between the medium and long lateral will lead one to take for R_t an approximated value of 10 ohms.

Resistivity at water level R_o = 1 ohm in neighboring wells.

$$S = \sqrt{\frac{1.0}{10.0}} = 32\%.$$

2) Formation water resistivity R_w

$$SP = -70 \log_{10} \frac{R_m}{R_w} = -105 \text{ mv.},$$

thus, $R_w = \frac{3.5}{31.7} = .11$ ohm BHT,
or 2500 G/G of NaCl.

3) Porosity p

$$F = \frac{R_o}{R_w} = \frac{1.0}{.11} = 9.1$$

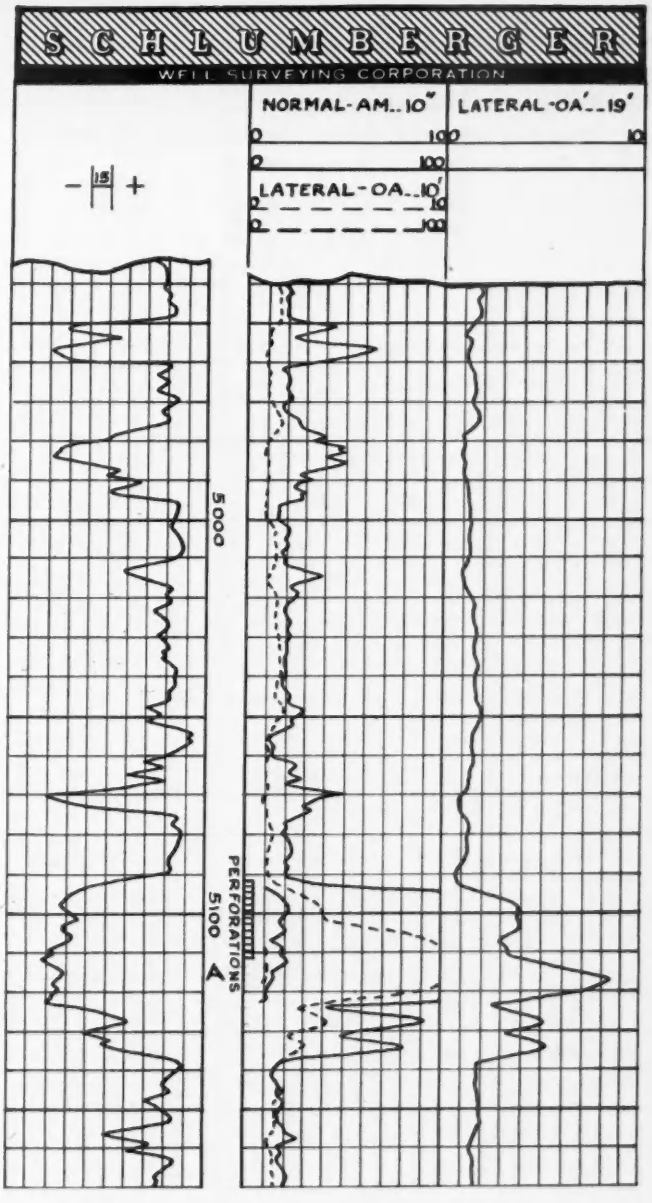
$$p = \sqrt[m]{\frac{1}{F}} = 29.5\% \text{ for } m = 1.8$$

CORE ANALYSIS

Average Porosity	27 to 34%
Water Salinity	2500 to 2700 G/G (Grains per Gallon)
Average Permeability	500 to 1500 md.
Residual Fluids	5 to 11% oil, 30 to 85% water

PRODUCTION RESULTS

Perforated	5092 to 5112
Flowed Est.	200-250 B/D, 20 API



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HOUSTON, TEXAS

How to Save, Reclaim *Mercury*

By JAMES O. KREBS
Southwestern Public Service Company
Charleston, W. Va.

WIDELY USED in gauging practices on both oil and gas production installations, mercury is a commodity which is frequently handled carelessly, with possible harmful results to personnel, and at an expense which, with a little care, can be greatly reduced. In this article, based on a paper presented before the Appalachian Gas Measurement Short Course, the author suggests ways to save mercury, as well as precautions to be observed when handling it.

PRACTICALLY all persons engaged in the installation and maintenance of gas measurement equipment have been faced with the aggravating problem of escaping mercury. These losses are primarily due to blowing drips, broken lines, freezes in orifice plates or gauge lines or unusual measurement conditions. In order to reduce these losses and keep measurement to a contractual degree of accuracy, mercury savers should be installed.

Several types of savers are being used which are adapted to different types of meters and measurement conditions. One is a drip, or reservoir, which will act as a mercury saver as well as a moisture collector. This saver should be equipped with valves or drain plugs and may be installed in either the vertical or horizontal gauge piping. Baffle plates will add efficiency to this type saver (Figure 1).

There is also the so-called "automatic" type which is installed at the top of the meter. This type collects the mercury as it is blown out and returns it to the manometer when the disturbing conditions have been corrected. This saver has two manometer connections and is usually mounted on the upstream side of the meter. It is constructed with the bottom slightly elevated so that the slope is extended toward the lower connection, giving the mercury a gravity pull into the manometer (Figure 2). Care should be taken in construction of this bottom connection so that the mercury will have a smooth surface over which to take the downhill run into the mercury chamber. The manifold piping extends inside the saver to within one-quarter inch of the top. Test connections can be made a part of this saver.

Reclaiming mercury which has amalgamated with other metals and contaminated with sand, dirt, grit and grease presents quite a problem and requires rather stringent cleaning methods. Distillation is the best mechanical process for removing foreign matter, but it can become a dangerous and tedious process and requires rather elaborate equipment to bring about proper results.

Mercury which contains only sand and grit can be made clean enough for use by passing it through a paper funnel which has minute holes at the apex, or squeezed through either wet chamois leather or closely woven cloth.

Mercury which has collected oil, paraffin or grease may be cleaned thoroughly enough for use by giving it a soap and water bath. Wash the metal in hot soapy water by agitation in an enameled or glass container and rinse in clear water until all traces of soap have disappeared. An acid bath with a 20 percent nitric acid solution can be used in the same manner. This method will generally remove enough of the amalgamated metals to make it usable again.

The method with which the writer is familiar and one which our company has found satisfactory, is as follows:

The equipment consists of two units. One is for an acid bath, the other for washing in distilled water. Each unit has two drying tubes and a 20-inch thistle-top tube with a trap at the bottom. The apparatus is firmly fastened to an upright stand which supports the tubes and provides places for the receiving vessels in each unit. Bulbs in the drying tubes are packed with gauze and the traps in the thistle top tubes are filled with chemically pure mercury. A sufficient amount of 20 percent nitric acid solution is poured on top of the trap of one unit and the other trap is covered with distilled water (Figure 3). After passage through the distilled water, and dried, it is ready for use.

Caution should be used in handling mercury, as it will attack many kinds of metal, especially gold and silver. Mercury can poison the body internally and externally. Fumes or vapors of mercury are destructive to body tissues, causing inflammation and swelling, and sometimes even death. The metal may be transmitted to the mouth by clinging under finger nails or rough skin. It can also get into open cuts or sores and cause dire results, so caution and cleanliness should be exercised when working with mercury.

An antidote for mercury poisoning is as follows: Wash the stomach with a stomach pump and give the patient the white of an egg or flour water to neutralize the acid effect. The patient should be induced to empty the stomach.

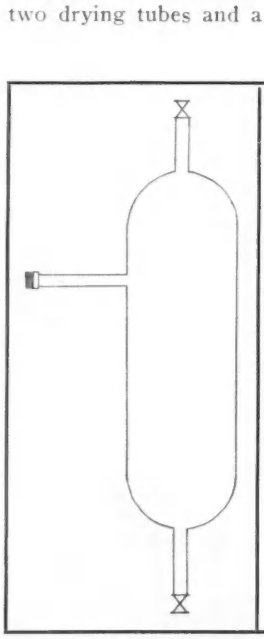

FIGURE 1

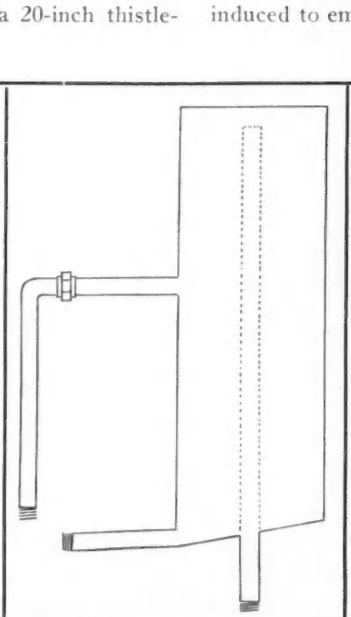

FIGURE 2

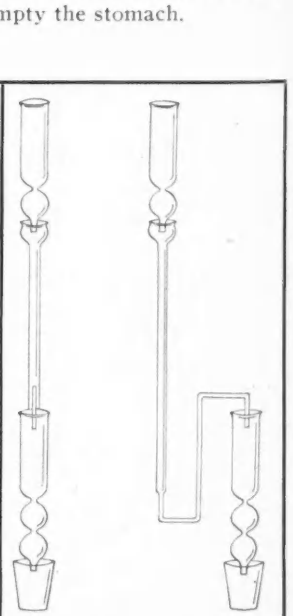

FIGURE 3

Selective Pressures Release

Bypassed Oil

By F. R. COZZENS
Field Foreman, Equity Oil and Gas Company
Stockport, Ohio

CONTINUOUS, intermittent and directional pressuring — the three energizing tactics most widely used in recovery of oil by air or gas drive —are discussed by the author and instances are cited to show where it is necessary to vary the plan of pressuring to accord with different types of formations and the change of fluid flow in them at various stages of the production cycle.

ECONOMIC completion of an air-drive, oil recovery venture is dependent to a great extent upon two factors:

1. The quantity of oil dislodged
2. The quantity of oil produced.

Unsuspected variations between these factors not only bottle-neck production on many projects, but also account for thousands of barrels of oil being left in the sand after recovery operations have terminated.

During the early days of air-pressuring, anywhere from 10 to 20 percent more oil was loosened from the sand pores than was brought to the tanks, mainly because of a belief which still exists in some quarters that any technique capable of driving oil from the pores was also capable of driving oil to the pumps. In a practical sense, that is not true. Fully 80 percent of all movable oil can be dislodged if sufficient energy is applied against it. Actual recovery of the oil, however, is dependent not only upon strength of the energy but also upon distribution of energy, and its action upon the fluid-flow system between induction centers and producing wells. Drainage through an oil-bearing formation is complicated, and due to diffusion of the sand layers and intervening lenses of shales and slate, its flow-course cannot be charted except in a general direction. No sandbody carries the same degree of permeability for any great distance, and strata of high and low permeability frequently intercommunicate.

Besides flow-trends which run parallel with the bedding-plane, there are angular and refractive trends, as well as barriers and disruptions along the capillary network. Largely due to the complex fluid movement, an unpredictable percentage of the movable oil is driven by the energizing process horizontally through the structure, and into channels which deviate beyond range of the pumps. With the collapse of pressure at any point along the route, much of this oil drains or recedes back into channels depleted of air, and becomes bypassed oil which was freed in the reservoir but not produced. The quantity remaining in the sand after pressure-collapse is largely determined by the fluid exchange between the zones, and the inter-zone reaction to the driving energy. If no provisions have been made for its recovery, this oil accumulates eventually in low-resistant areas of the reservoir and is invariably lost because wells which should have produced it have already been abandoned.

More or less displaced oil can be discovered on practically every lease which is being, or has been, air-pressured, and the predominating indication is the finding of oil pockets at diverse odd places within the sand structure. If new wells are drilled while pressuring is in progress, oil pockets are likely to be encountered in the gas cap, or extreme top zones of the sand, revealing that some dislodged oil, at least, is being forced horizontally, and is being held or trapped in that area until the energy is released. Another favorable location for oil pockets at this stage is immediately below beds of shale which have obstructed the flow channels. If redrilling is done after the pressured project has been abandoned for some time, oil pockets are far more common in the low recesses of the reservoir, and considerable free oil is likely to top the water-level above the bedding planes.

Flow behavior of displaced oil has occasioned wide study during the past ten years, especially by operators of the early air-gas pressured fields of Ohio and West Virginia, and their efforts have revealed two very important facts: (1) that a migration of displaced oil into low resistant sand areas begins immediately after pressure collapse; and (2) that at various times the migrating oil enters and passes through zones favorable for drainage to producing wells. Further experimental efforts, conducted on pressured leases which had previously been aired one or more times, also revealed that a high percentage of this oil is recoverable, provided the pressure buildup is unbalanced between sand zones at certain intervals to allow migrating oil to reach areas favorable to drainage. The technique, commonly termed "sand squeezing," is actually a phase of selective pressuring, and is planned to provide "up and down" (inter-zone) flow movements as well as parallel movements through the formation. The object is to keep the oil in motion until it reaches the pumps.

Inter-zone energizing processes can become a part of the air-pressuring schedule on any project having zoned input wells. In areas where sand permeabilities are fairly uniform, unshot wells are often converted to inputs by setting one or more packers along the sand column, so the producing horizon can be separated into compartments. If old wells are not available for zoning purposes, the practice generally followed by eastern operators is to drill new inputs at strategic points on the project before pressuring is started. The annulus of each prospective input is planned so that at least a six-inch bore-diameter can be retained through the top sections of producing sand. This permits further reductions in bore dimensions so that one to three packers can be shoulder seated along the sand column, and still have space through the annulus for air lines of adequate capacities. Maximum top bore diameter, however, can be carried through the entire length of the sand column, if desired, and the packers anchored against the walls at required locations. In sand columns being zoned in accordance with variations in permeability, steel line measurements are essential in making packer locations. In fairly uniform sands, one to three

packers are seated along the column, depending upon its length, at the owner's discretion as to location. These zones are seldom made equal in length, but all packers which separate them are seated firmly against pressure leakage. A coating of plastic compound or cement slurry is generally sprayed against the bore-walls at the specified location before the packers are run.

Line pipe or tubing, in diameters of 1 to 3 inches is used to conduct air down the annulus, and in wells having a very short sand column (less than ten feet), only one separation is made, and the inner string of casing serves as an air conductor to the top zone.

While zone-separation at the inputs is of major importance in dispensing driving energy through the proper sand spheres, a high degree of cooperation is also necessary at the opposite end of the flow route in order to motivate the maximum quantity of loosened oil to the pumps. The producing well, therefore, is of importance equal to the input, and if new ones are drilled, the most widely approved practice is to provide sand bore diameters equal to, or greater than, those of the inputs. Principal objective of the larger bore-diameters is to back up selective pressuring efforts with corrective shooting practices. A six inch diameter sand bore permits the safe running of torpedo shells in diameters up to 5½ inches, which gives a maximum shot concentration of 4.4 quarts of liquid nitroglycerin per foot of sand in very tight and restricted zones.

Stub shells are generally used, and in most sands, the top of the shell may extend to within 2½ feet of a casing shoulder without causing damage. All loose, and especially pebbly sand is shot lightly, 1 to 3 quarts of liquid nitroglycerin per foot being the rule. Hard shooting of loose, porous sand strata not only causes excessive shattering, which increases cleanout time, but is now believed to also be the major reason for pockets of bypassed oil, commonly found in fracture areas after air-pressuring has terminated. Spacers are used between stub shells at locations along the sand column where it might prove necessary to set packers.

The bore is thoroughly cleaned and washed down after shooting, and it is now customary to allow a waiting period of 24 to 36 hours before the newly-cleaned well is tubed, the purpose being to detect any water avenues which may have been opened by the shot. Avenues or strata found yielding excess water are sealed off with plugging compounds, or by the use of cement.

New producers are generally drilled between old wells of proven worth, where the probable distance between fracture patterns is too great for effective drainage. The most prominent among the old producers are cleaned out, casing checked for leakage, then fitted in most cases with new pumping equipment. Old wells of unknown behavior, but still capable of producing oil, are usually not operated during the early stages of pressuring. The practice most widely used on such wells is to clean the shot hole, and place a drillable plug in the sand-top. This guards the annulus against pressure leakage from the reservoir, and permits the well to be reopened and pumped, if and when the need arises. Well arrangements (spacings) are made to take advantage of directional dips in permeability trends as much as possible, and no distinct pattern is followed.

Drainage Performance

Despite the best known arrangement and mechanical engineering of wells, the drainage performance through a given area of sand can not be predetermined with any great degree of accuracy. Many of the flow-processes especially among pores and capillaries, are not fully understood, and to obtain a practical working knowledge of drainage response, it is usually advisable, in the initial stage of an air-gas drive, to apply the energy gradually and continuously until a pressure buildup is established in the sand. Induction ratios of energy into segregated zones at the inputs are largely determined by analysis of sand samples taken from divers locations on the project. In fairly uniform sands which have been segregated without regard to permeability strata, the inducted energy is alternated among the zones at the operator's discretion.

After the required pressure buildup is established, and wells nearest an input have reached their peak in production, inter-zone, or selective pressuring begins by reducing pressures still further on porous strata, while force against tight and restricted areas is increased in proportion. Reductions and increases are made very gradually for a period of three to five weeks, at the end of which time the force against the porous areas is practically nil. Pressuring tactics are then reversed for a similar period. That is, pressures in porous zones are allowed to build up, while those in restricted zones are decreased. On the majority of pressured leases, the difference in force maintained during cycles, between tight and porous sand-zones averages 50 pounds per square inch.

Input induction rates at this stage are largely a matter of choice among operators, a typical example being 500 cubic feet per foot of sand per 24 hours. Well performance is observed closely during cycling, and if, after four or five short cycles, the general production rate of a pattern shows improvement, the cycle-periods are lengthened by adding 48 to 60 hours to each. This phase of pressuring, which always begins after production has peaked on the first pattern, continues throughout the remainder of the project's life in much the same manner, except for one important variation. In the latter stages, the maximum force which was applied at the start to the zones of lowest permeability is increased considerably, so that a pressure variation between tight and porous zones of 100 psi. is not uncommon. The purpose of this action is twofold: (1) to replace more of the air space in the porous zones with fluid; and (2) to retard channeling, which in itself is a major cause of bypassed oil. Consequently, more oil is driven from the tight sand sections into areas of low resistance (porous zones) where it can be forced on to the pumps with much less effort and expense.

When the quality of produced gas over a pattern (taken as a unit) tests in excess of 85 percent (air) a cycling process begins at the producing end of the drainage system to further back up cycling which is being continued on the inputs. The technique is put into action by closing in two or three producers in a pattern showing a very high air rate. Selected wells are shut in for a period of 36 to 40 hours, then allowed to blow off, given a resting period of three hours and put back on the pumps. Three such cycles are applied to these wells each month, and during their off-cycles all remaining wells in the pattern are given similar treatments for like periods of time. A continuous cycling rotation is thus brought gradually into action over all the patterns, and cycling of producers, as cycling of the inputs, is also maintained throughout the remaining life of the project. A "breathing" action which distributes energy to better advantage is established in the sand, and this aids in divers ways in the maneuvering of oil into favorable drainage channels. The local effect is a slugging action within the pumping radius of each producing well, which stimulates fluid movement through the shot fracture-pattern and clears the drainage outlets along the sand face. The general effect is a back-flow and a cross-flow of energy which temporarily unbalances pressures along the main flow-route between the input wells and producers.

When the general production decline reaches the stage where many of the producers can no longer be pumped at a profit, the final phase of inter-zone pressuring is introduced. The fluid column, which has previously been kept comparatively low, is now encouraged to

rise in the sand, and pumping equipment in the remaining producers is rearranged accordingly. This technique is commonly termed a "water lift" and reasoning for it is that as pressures in the upper zones become weaker by excessive air waste from producing wells, any dislodged oil remaining in those zones gravitates into the low sand areas. Some water, at least, is always present in the sand base, and receding oil is caught naturally on the crest of this flood. Therefore, if the fluid level can be raised sufficiently, the oil can be floated into upper zones where enough energy remains to drive it on to the pumps.

Fluid Level Rises

Fluid level in many sands rises naturally as pressures are relinquished in the upper zones. In most cases, however, some method of stimulation is necessary. Where water (connate) reservoirs are known to exist within the sand bedding-plane, or immediately below it, a satisfactory water rise can be induced by shooting the pockets of abandoned producers (located at strategic points) with light charges of nitroglycerin (10 to 15 quarts), then placing a pressure-tight plug in the sand top. The general practice is to so treat two or three wells in each pattern. Self-induction of the water through the required strata to nearby producers is fairly rapid, especially if the low sand has been channeled by air. However, in some states, a permit is required for this practice. Since compressors and pressure lines are still in use, a more practical method of raising the fluid column is to perforate the air induction line in the base of certain inputs, allowing maximum energy to be driven into the desired areas. Another favorite induction avenue is an abandoned producer, into the pocket of which a two-inch diameter air line is run on a packer. Both line and packer can usually be removed from the annulus when the pressuring requirements are completed.

Cycling of air energy, supplemented by the final water lift, terminates the economic life of the project, and completes a setup which has combined the principles of continuous, intermittent, and directional pressuring — the three energizing tactics most widely employed in a recovery of oil by air-drive. The initial phase of the setup is designed primarily to dislodge oil. The second phase is planned to keep dislodged oil in motion, and to maneuver it into areas favorable for drainage.

In actual field usage, this dual effort is proving successful in more than 85 percent of the cases tested. More oil is being brought to the tanks, and consequently, less oil remains in the sand.

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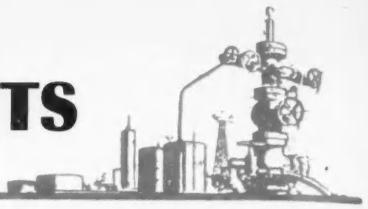
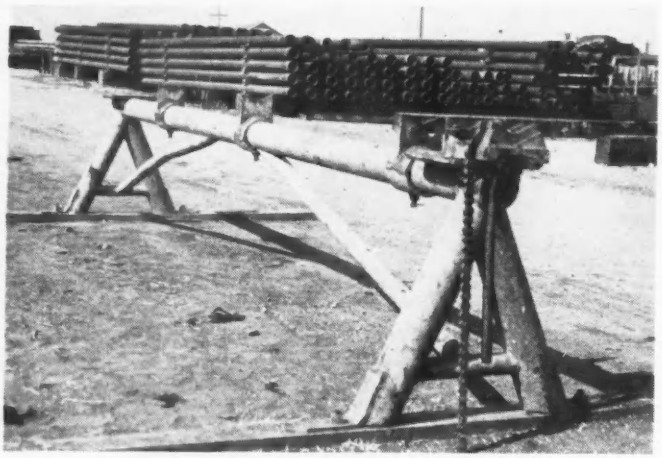
PRODUCTION HINTS



$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

HOW TO—Fabricate Pipe Yard Work Bench

When pipe is brought in from the field for storage and is to be used on a future job, the fittings and collars may be removed at a central work bench. This bench is also useful in prefabricating sections of pipe to be placed in gas or crude oil lines.

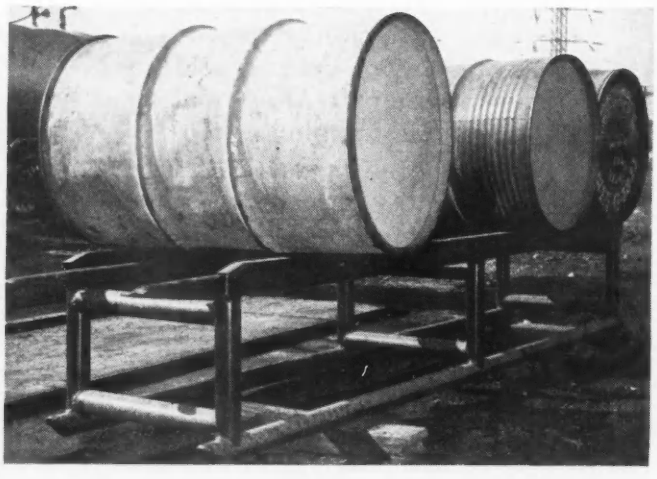


The bench is designed for its job, and because of its construction, cannot be conveniently used for any other purpose. It is made of salvaged 4½-inch drill pipe and is essentially a long "horse" with A-frame supports at either end. The bench stands approximately 35 inches high and is about 15 feet long. Added support is given the legs by two-inch pipe braces welded to the under side of the horizontal member.

A one-half inch steel plate measuring about 12 by 18 inches and welded to one end provides a sturdy foundation for the pipe vise which will accept various sizes of pipe up to 10 or 12 inches in diameter. V-notched pipe rests are provided along the horizontal member to steady the pipe being fabricated or disassembled. These notched rests are made of heavy plate steel and are welded to short pipe nipples slightly larger than the outside diameter of the drill pipe. These pieces are set in place during fabrication of the work bench. A hole has been cut in the lower side of each nipple and a nut welded to the nipple so that a bolt may be screwed through the nut to act as a set screw for the pipe rest to prevent its turning or sliding. Each leg of the bench has been secured to a heavy piece of timber which serves as a foundation.

HOW TO—Rack Oil Treating Chemical Drums

One of the jobs performed by the lease pumper is to fill the chemical feeder with treating fluid when the chemical level becomes low. This can be done with a bucket or can filled with chemicals taken from a larger supply drum kept near the well. Since it is convenient to have these supply drums elevated so the bucket can be held below the spigot, an elevated steel framework of salvaged pipe serves this purpose.



Courtesy Lincoln Electric Company

This sturdy storing rack for drums of oil treating chemicals as well as lubricating oil for pumping equipment is a skid platform with built-in loading ladder. The structure is about 28 inches high, 40 inches wide, and 10 feet long. The skid runners, cross pieces and supporting uprights are of three-inch pipe. The top runners are channel iron welded to the structure so that the channels face each other as shown. The top edge of each channel has been beveled at the end to facilitate loading the drums on the rack.

The loading ladder telescopes into the channel steel top runners, and is of 1¾-inch pipe welded together with cross pieces to resemble a ladder. Both feet of the ladder are beveled at an angle to rest flat on the ground when extended from the rack. A low angle rise to the rack makes it possible for one man to roll a filled drum from ground level onto the rack for dispensing. The rack can easily be moved.

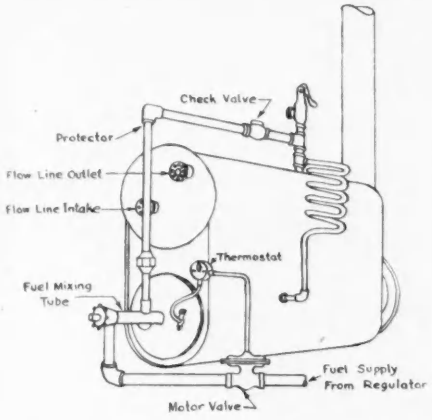
PRODUCTION HINTS

HOW TO—

Protect Water Shell Of Flow Line Heater

Fire tube, indirect heaters have found wide application in the reduction or elimination of hydrate formation in high-pressure gas and gas-condensate production. Heat is transmitted from the fire tube bundle to a heating medium, primarily fresh water. Operating temperature of this type is about 190° F. The flow tube bundle handling the high-pressure gas is emersed in this hot water and the heat is transmitted to the gas. By elevating the gas temperature above the hydrate temperature at operating pressures, steady flow is assured.

While this type unit has been built as carefully as possible to eliminate a fire

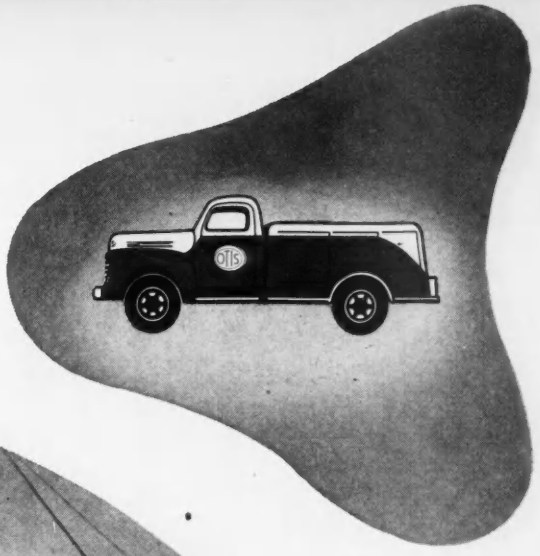


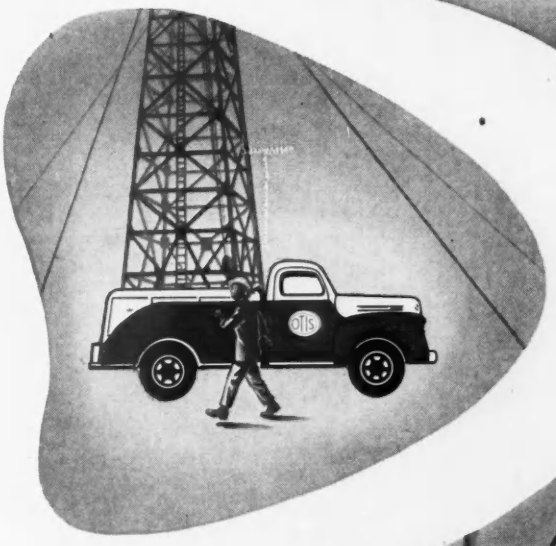
hazard, or to prevent the unit from blowing up, this idea was incorporated on the indirect heater as an added precaution against a thermostat freezing or becoming inoperative due to contact with oil or other liquids. In such an event, the flow of fuel gas would not be controlled and would permit the water to form steam and possibly damage the water shell enclosing both the fire tube and the flow tube bundle.

In order to prevent such an accident, a protecting device was added to the heater. It is essentially a method whereby steam formed in the top of the water shell would overcome the fuel gas pressure and enter the mixing burner to extinguish the fire in the fire box. It is a small bypass line connected to the pressure popoff valve mounted on top of the heater, equipped with a check valve and taps into the fuel line at the fuel mixing tube as shown.

Normal operating pressures of the fuel line are greater than the pressure inside the water shell, and therefore the bypass valve is held closed by this differential.

one of OTIS' new two-tone field trucks





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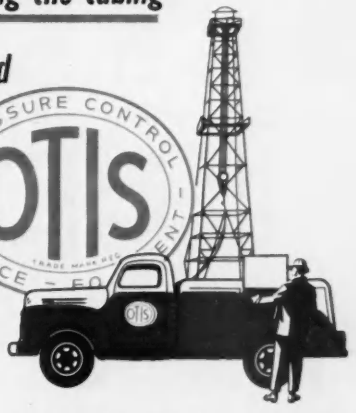
PRESSURE CONTROL OTIS SERVICE – EQUIPMENT



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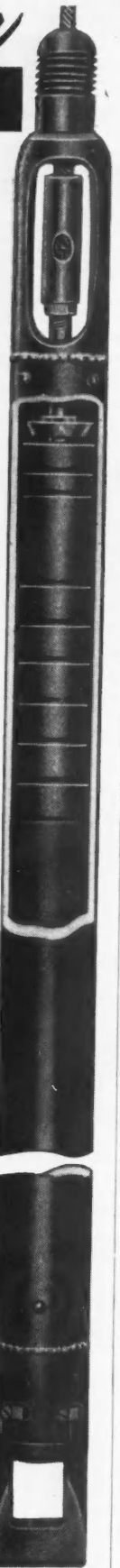
Miller SAND PUMPS



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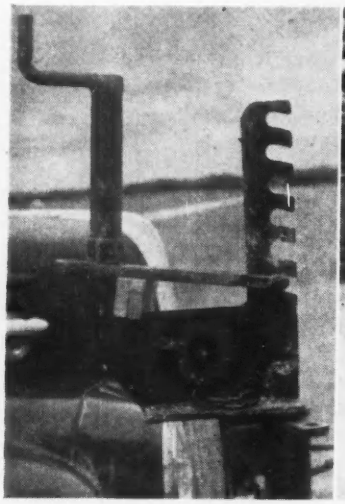
PRODUCTION HINTS

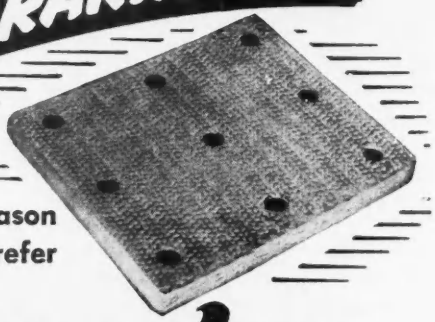
HOW TO—Fasten Pipe on Truck



A simple device for holding loose joints of pipe in place on the lease truck may be fabricated from scrap material. A firm support is welded to the front bumper and grill guard and a similar one is fastened to the side of the truck bed. A one-foot section of I-beam is then welded to the top of the upright at right angles to the truck bed. A section of one-half inch scrap iron is then notched on one side as shown and another piece is slotted on the end to fit the various notches. A one-inch bolt is welded to the other end of the beam and a one-foot piece of 1¼-inch pipe is welded to the top of the nut for the bolt. A piece of sucker rod material is bent into an L-shape and welded to the top of the pipe to make a crank.

When joints of pipe are to be moved, the nut is unscrewed and the slotted bar removed. The pipe is then loaded into the space between the bolt and the

SMOOTHNESS OF BRAKING...



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notched bar. The slotted bar is then replaced and the nut cranked down. This method prevents the pipe from "swarming" during moves and possibly injuring a workman.

HOW TO—
Speed Connection of Flow Line in Field

Making up flow lines in the field can be speeded with a simple, efficient pipe jack. The jack is a two-legged collapsible frame held in position by the weight of the supported pipe.

Main section of the jack is made of a seven-foot length of 1½-inch pipe, to which has been welded six half rounds cut from a salvaged piece of 5 3/16-inch casing. These half rounds are welded to the 1½-inch leg at ten-inch intervals and

are reinforced with short pieces of plate steel.

Approximately 4½ feet from the lower end of the pipe jack is a hinge which connects the jack to a 4½-foot support made from one-inch pipe. This supporting leg can be inserted into the ground to hold the jack at the desired height. Its adjustability makes it possible to raise the working end of flow lines any convenient height above ground. When not in use, the jack folds into a single section for easy moving. It is designed primarily for small-diameter field flow lines up to three or four inches, but a heavier unit could be made for larger pipe.

When a flow line is being laid, the jack is placed under the end of the line in the proper slot and the jack raised and the brace set. If the line is being laid by one man, the jack will stand by itself while the joint is being made. Being collapsible and requiring little space on a truck, it will stand rough treatment.

KINZBACH Announces...

THE KINZBACH Automatic MUD RELIEF VALVE

The *Only* Mud Valve with *Positive Snap Open—Snap Shut* Action

At last positive automatic relief of overload pressures in mud lines is possible. The new Kinzbach Model 112 Relief Valve provides safer, more efficient pump or pressure relief and greater flexibility in operations than any other valve.

The Model 112 operates on working pressures from 750 to 2500 p.s.i. It Snaps Open for instantaneous pressure relief at maximum volume. It Snaps Shut to restore circulation instantly and automatically after a pre-determined pressure drop.

The Model 112 Valve can be used for any mud relief application, including compounding operations. Field tests prove conclusively that the Kinzbach Valve offers every operational advantage required for efficient mud operations. Write for full technical data. Ask for bullentin 11250.

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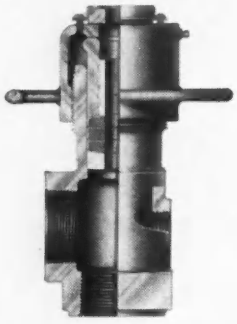
NORRIS STUFFING BOXES



The NORRIS "T" Type box eliminates use of a Tee fitting to connect on to lead line. "Pull-through" Type allows all internal parts to pull out through the box with the Polished Rod.

For information on other NORRIS Stuffing Boxes, write for Bulletin No. 32.

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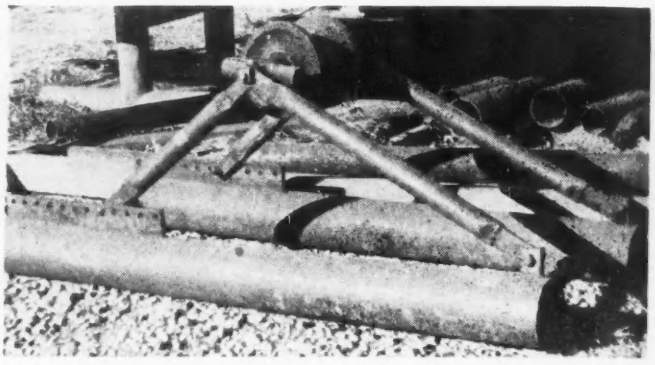
SPECIALIZING in MODERN SECONDARY RECOVERY

HOW TO—Build Adjustable Dolly



A convenient labor-saving device to have around the storage yard is a portable pipe handling dolly to carry pipe endwise at variable heights.

A rectangular bed of two pieces of four-inch pipe approximately 5½ feet long, with a spacer of two-inch pipe welded to the sides of the four-inch members at each end, formed a substantial footing. Pieces of rectangular steel, three-fourths inch thick and with a center hole large enough to accommodate a five-eighths-inch bolt, were welded to the top of the four-inch footing members directly opposite each other for hinge brackets.

One-half inch thick flat steel bars with equally spaced five-eighths-inch holes were welded to the opposite ends of the four-inch horizontal bed members. Legs were made of four short pieces of 1½-inch pipe by welding short rectangular steel bars to their ends. Holes large enough to accept bolts for hinge pins and roller shaft were cut in the rectangular ends of the legs.

A pipe roller was mounted between the vertices of the two sets of legs. Short pieces of 1¼-inch pipe with holes cut midway through their sides were used as centering spacers for the roller.

By removing and replacing a bolt at the foot of each adjustable leg, the vertical angle between the legs is changed, thus raising or lowering the height of the roller within the limits of adjustment.

HOW TO—Equip Field Pickup Truck

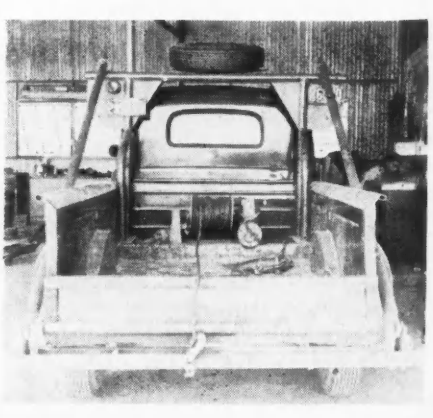
Many jobs around oil leases are too light to require the services of a regular truck, yet are too heavy for a light pickup. However, a pickup may be equipped to do many jobs that would otherwise require the services of a large truck.

At the front end of the bed, a light winch is installed with power takeoff to the engine's drive shaft. This equipment permits heavier loads to be handled than would ordinarily be hauled if loaded by hand.

The rear bumper of the truck is reinforced and carries a clevice at either end to which boomer poles are attached. These poles lie upon an extension of the headache post when in the over-the-road position as shown. When heavy material is to be handled, the boomer poles are raised and the hairpin installed at the top to make them ready for lease work. This makes the entire unit available for hoisting and pulling as well as regular hauling duties.

Additional space is provided in the truck bed by mounting the spare tire over the cab instead of under the bed which in the reconverted model is blocked off by the reinforced bumper.

One-fourth inch steel plate forms the platform on which the tire is mounted, and is welded to the horizontal headache post supporting the gin pole members as shown. General utility of the truck has been multiplied through these few additions.



Kilowatt Hours and CUBIC FEET by the Billion

By W. T. THAGARD
Administrative Engineer, Texas Eastern Transmission Corporation

ELECTRIC POWER for driving gas trunkline centrifugal compressors and average cost for power on the two "Inch" lines as gas carriers are discussed. The paper is substantially as presented before the 21st Annual Meeting of the Petroleum Electric Power Association at Beaumont, November, 1949.

TO THOSE of us in the gas industry where a cubic foot is the commonly accepted unit of measurement, we are accustomed to speaking and thinking in terms of thousands, millions and billions of cubic feet of gas. Generally, most gas men think of kilowatt hours as a competitive fuel in the sale of such domestic appliances as ranges, water heaters, refrigerators, etc.

In the past several years, however, some gas men have thought about kilowatt hours, as a matter of fact about a billion kilowatt hours, not as a competitive fuel for domestic appliances, but as an essential in the transportation of billions of cubic feet of natural gas. I refer specifically to the men of the Texas Eastern Transmission Corporation, where by the use of electrically driven centrifugal gas compressors about a billion kilowatt hours are used annually in the transportation of natural gas from the Gulf Coast to the Appalachian and Eastern seaboard areas.

Texas Eastern Transmission Corporation was organized in 1947 for the purpose of buying the "Big and Little Big Inch" oil lines and using them for the transportation of natural gas. The "Big Inch" line originated at Longview, Texas, and terminated at Linden, N. J. It consisted of 1264 miles of 24-inch and 130 miles of 20-inch pipe. The "Little Big Inch," a 20-inch line, originated in the Houston and Beaumont, Texas, area and also terminated at Linden, and was approximately 1475 miles long.

Both lines were operated with electrically driven centrifugal pumps. The "Big Inch" line had 27 stations with an installed horsepower of 128,450, while the "Little Big Inch" had 30 main line stations with 113,800 horsepower installed. To operate the lines with a minimum of personnel, they were converged at Little Rock, Ark., and from there on the lines are on a common right-of-way with the pump stations of both lines being on the same site. Although the lines were physically separated and operated independently, the 23 stations north of Little Rock were in reality dual stations.

As part of the conversion program of the lines from oil to gas, inquiries were made in February, 1947, of the engine manufacturers to determine their approximate delivery dates of gas engines. These inquiries led to a proposal to build a centrifugal compressor using an electric motor drive. Such a proposal was interesting and immediately appealed to the company, as it presented possibilities of better utilizing the facilities that were being purchased, especially the electric facilities.

The principal electric facilities included in the purchase were 86 1250-horsepower motors, 84 1500-horsepower motors, and 54 3750 KVA transformers, or a total of 233,500 horsepower in major motors and 202,500 KVA in major transformers with the necessary related switchgear and substation equipment.

The proposal was so appealing that Texas Eastern began an immediate investigation of the practicability of the use of centrifugal compressors with electric motor drive. This investigation revealed many things among which were: (1) Centrifugal compressors had not previously been used for long distance gas transmission. (2) They had not been used for pressures more than 500 pounds per square inch. (3) There was some question as to the ability to obtain a satisfactory seal for this service at these pressures. (4) Considerable progress had been made during the war, both in techniques of their manufacture and the materials that go into their construction. (5) Maintenance and operating costs, other than fuel, were estimated to be considerably less than for gas engines. (6) The centrifugal compressor is essentially a high capacity machine. (7) First cost of the compressor and motor with the necessary electric station equipment was in line with other compressing equipment. (8) More gas could be delivered to the market, as no gas would be required for fuel. (9) Economic studies indicated that the price which could be paid for electric power was in the range of that which was paid during the operation of the lines for oil service. (10) The use of centrifugal compressors in conjunction with existing electrical facilities would allow an earlier date for increasing the delivery capacity of the lines.

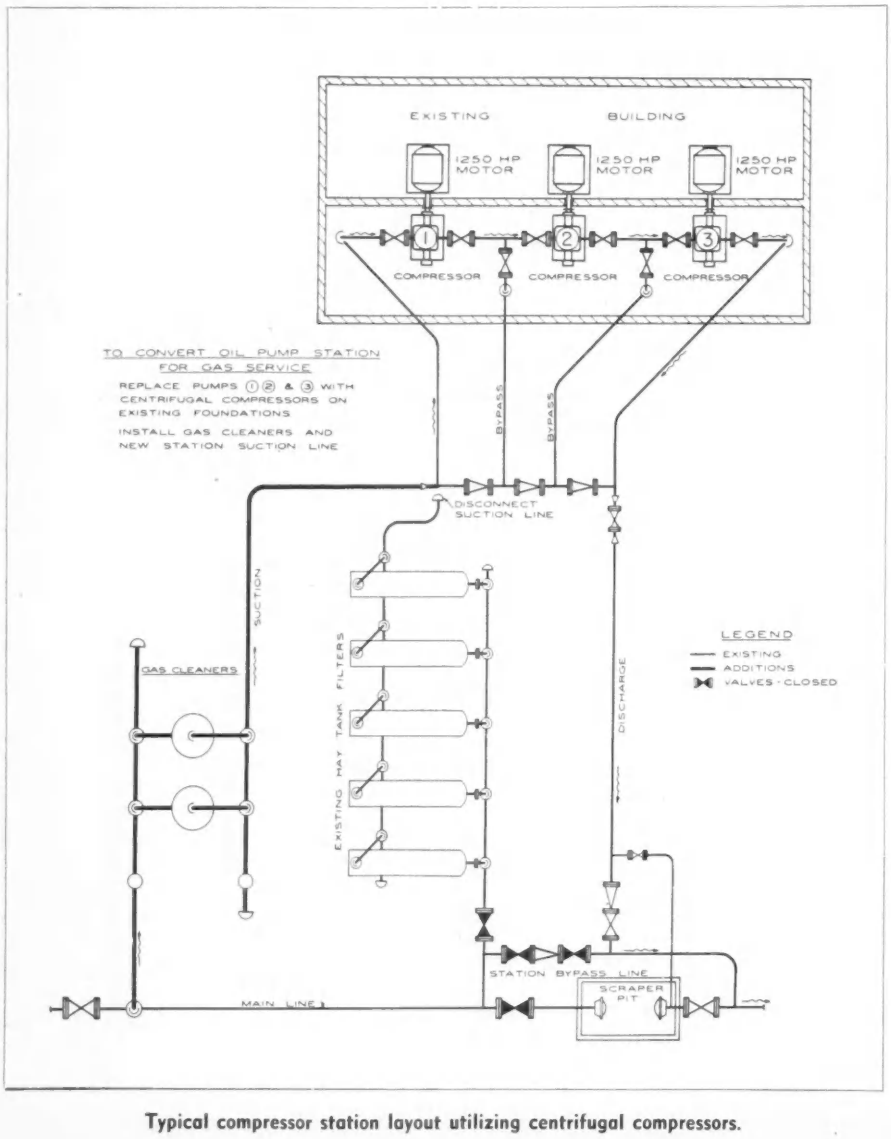
The use of this equipment as revealed by these investigations presented problems, none of which, however, appeared to be incapable of solution. After consideration of all factors involved, it was decided that electrically-driven centrifugal compressors would be used for the transportation of natural gas through the "Inch Lines." The existence of the electrical system, one of the major facilities at each station, was an important factor in making the decision to use centrifugal compressors with electric motors.

The compressors were designed to fit the foundations and piping in the existing pump houses so that the oil pumps could be lifted from their foundations and replaced with the gas compressors. This arrangement established the physical design of the compressors as a double suction unit, similar in appearance to the liquid pumps. The compressors were designed to operate at 3600 revolutions per minute. By this design the 1250-horsepower, 3600 rpm, 2300-volt squirrel cage induction motors from the 20-inch line could be used as direct connected prime movers. The motors from the 24-inch line operate at 1750 rpm, and could not be used without gears. It was not planned to use these motors.

It was determined that with a com-

pressor design capacity of 225 million cubic feet per day, a compression ratio of 1.3 could be developed in three stages and the horsepower required would not exceed the limitations of the 1250 horsepower motors. Therefore, by operating the 20- and 24-inch pump stations in parallel, the capacity of six single stage centrifugal compressors would be approximately 450,000 MCF per day with a discharge pressure of 750 psi. To operate the lines in parallel, each dual station would require crossover ties on both the suction and discharge sides of the station. Such a design meant that practically all of the existing electrical facilities at each station could be utilized with the exception of the 1500 horsepower motors, brought to a minimum the number of changes necessary in piping and electrical facilities, and required no change in the pump station structure. This was deemed advisable due to the National Security provisions in the purchase agreement which require that the property shall be restored to use as an oil carrier in 90 days in the event of a national emergency.

As a necessary part of the investigation for the use of electrically driven centrifugal compressors, a survey was made of the 19 power companies which had served the requirements of the War Emergency Pipelines to determine if they could serve the loads that might be required, and what rates would be available for such power. At that time, 18 months had elapsed since power had been required by these lines and much of the power previously supplied had been sold to other customers. In 1947 most power companies in this country were facing a critical shortage of generating capacity, and many transmission lines were loaded almost to the breaking point. The areas through which the lines passed and where power was required were no exceptions. At some station locations, it was immediately determined that power could not be obtained in the quantity and at the time desired, or that the expenditure to get the power was economically unsound. This survey of the power companies also indicated that at locations where the power would be available, the rates would approximate those paid by the War Emergency Pipelines. The ability to purchase power at these rates meant that the electrically driven centrifugal compressors could be operated within the limits as indicated by the economic studies. At certain station locations where electric power could not be obtained, other forms of motive power would be required, and it was decided to use reciprocating gas engines at these locations.



Typical compressor station layout utilizing centrifugal compressors.

When Texas Eastern began operation of the lines in May, 1947, and prior to the installation of any compressing equipment, the lines were delivering approximately 140 million cubic feet a day to the Appalachian area. This was accomplished by taking gas into the lines at approximately 800 pounds pressure from the fields and in effect floating the gas to the delivery points.

The second step in the use of the "Inch" lines for the transportation of natural gas was the installation of gas compressing equipment for a design capacity of 433 million cubic feet per day. This design called for 21 compressor stations with an installed horsepower of 153,500. Of the 21 stations, five were of the reciprocating type with a total of 36,000 horsepower, and 16 were electric drive centrifugal stations with a total of 117,500 horsepower. The estimated electric power demand for the 16 centrifugal stations was 76,700 kilowatts.

Late in 1947 a sales contract was made for an additional 75 million cubic feet per day to be made available in the winter of 1948-49. This meant a redesign of the system for a total capacity of 508 million cubic feet per day.

The redesign for the increased capacity required 231,450 horsepower. The installed horsepower would total 245,150, with 171,250 horsepower in electric motors and 73,900 horsepower in gas engines. Retained were the same total number of stations but two locations were changed; distribution was 14 centrifugal and seven reciprocating. This change resulted from a desire for more flexibility in operations and a shortage of electric power at one location. With reciprocating engines the compression ratios may be varied, whereas with compressors using a constant speed motor, only a relatively constant compression ratio can be obtained.

The change in capacity design in most instances increased the power requirements for the centrifugal stations. This in itself presented a problem since the initial requirements for power would have been a strain on the existing facilities of most of the power companies. A survey of the nine power companies required to serve the centrifugal station requirements indicated that by the time the construction program was completed the power requirements could be met. Due to the shortage of generating capacity this power was made available with the un-

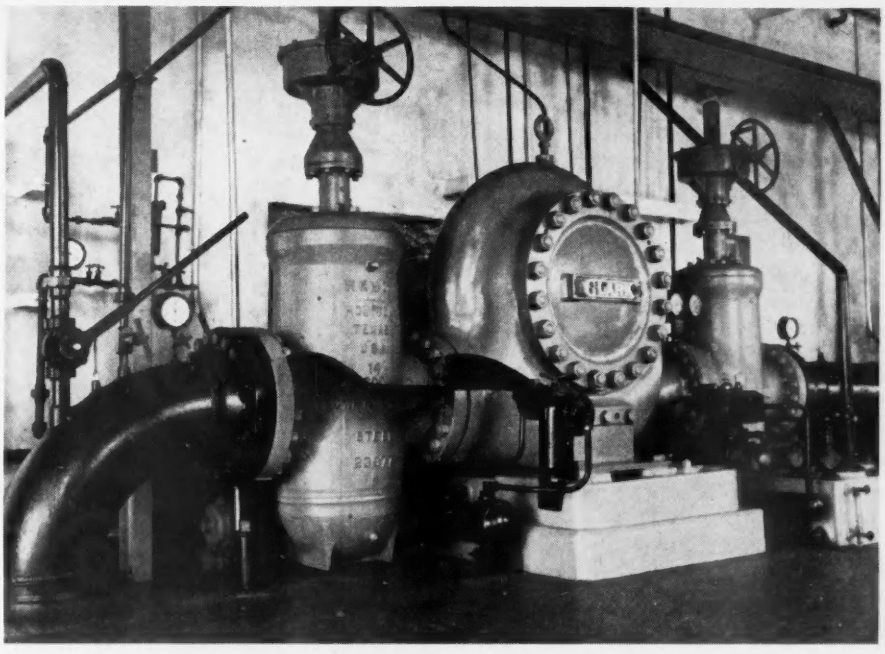
derstanding that in certain peak demand periods of the power companies, some curtailment of the load might be necessary. The type load offered by the centrifugal compressor stations was in general attractive to the power companies due to the anticipated high load factor at which these stations would operate. It was contemplated that the system would operate with an annual capacity factor of about 95 percent with an estimated electric power demand of 126,000 kilowatts.

The new design called for a total of 107 motors with the following size breakdown:

Number	Horsepower
34	1250
24	1500
21	1750
28	2000

The existing 1250 horsepower motors were reinsulated or rewound to increase the horsepower to 1500 and 1750 horsepower motors respectively, therefore taking care of these size requirements, but the 2000 horsepower motors had to be purchased. This, incidentally, was the only major electrical equipment that had to be purchased.

In 1948 additional sales and purchase contracts were made to again increase the capacity of the system. The increased capacity this time meant not only the activation of additional original compressor stations on the "Inch" lines, but additional pipe lines. This increase was to be effected by the purchase of 235 million cubic feet per day at Compressor Station 16 near Lebanon, Ohio. This will make a total delivery capacity on the north end of the system approximately 740 million cubic feet per day. In the agreement for the purchase of this gas, Texas Eastern was to sell this same gas transmission company 200 million cubic feet per day near Lisbon, La. The combined sales capacity on both the north and south ends of the system will approach one billion cubic feet of gas per day. All of the compressor station facilities for this capacity were to be ready by January 1, 1950, while all of the additional pipe lines will be complete before the middle of 1950.



One of the electrically-driven centrifugal compressors on the line, showing method of mounting on base formerly supporting centrifugal pump of the "Big Inch" oil system.

The additional pipe line facilities for this increased capacity are 178 miles of 26-inch loop line in Ohio, 38 miles of 20-inch loop line in Louisiana, 33 miles of 20-inch loop line in Texas, and 115 miles of 16-inch from the end of the "Little Big Inch" line near Baytown, Texas, to Provident City, Texas. For the increased capacity, five new compressor stations were necessary and modifications to the compressor stations north of the station near Lebanon. Four of the new stations are on the "Little Big Inch" line, three being at existing station sites, and the other about half way between Beaumont and Houston. The fifth station is adjacent to the existing station near Lebanon.

Of the five new stations, three are reciprocating and two are electric drive centrifugal. The total new reciprocating horsepower is 15,000 and the centrifugal horsepower is 7500. Modification of the existing stations on the north end of the system added 9750 centrifugal horsepower. The horsepower required for the total system will be 258,000 with a total installed horsepower of 277,400, of which 188,500 horsepower is electric drive centrifugal. The total number of major motors is now as follows:

	Horsepower
30	1250
19	1500
22	1750
42	2000

It is estimated that with the entire system in operation the total demand will be 139,000 kilowatts and will require approximately 1120 million kilowatt hours annually based on a 95 percent capacity factor to deliver 326 billion cubic feet of natural gas.

Several times this paper has referred to load factor or capacity factor. On an annual basis in operations of the pipe lines these terms become synonymous. The operation of the Texas Eastern System has always been anticipated as a high load factor operation. For the first ten months of 1949 the system operated at an 85 percent capacity factor, and it was estimated that the annual capacity factor for that year would be about 87 percent. For individual stations a 90 percent electrical load factor for a month has not been uncommon.

Of importance is the number of interruptions due to a failure of power supply. This is extremely important in our operations as at the present time in both centrifugal and reciprocating stations their operation is entirely dependent upon pur-

About the Author

W. T. THAGARD, administrative engineer with Texas Eastern Transmission Corporation, is a 1934 graduate of Rice Institute, Houston, with a B.S. in chemical engineering. From 1934 to 1935 he worked in oil field and pipe line construction with Magnolia Petroleum Company and Humble Pipe Line Company, and in 1935 he became industrial gas sales engineer with Atlanta Gas Light Company. From 1941 to 1946 he served in the Army and was discharged with the rank of lieutenant colonel. In 1947, after eight months as vice president and manager of North Carolina Gas Corporation, and a year as a rate consultant with Ebasco Services, Inc., he joined Texas Eastern Transmission Corporation.

chased electric power. For the first ten months of 1949 station down time resulting from a failure of the power supply was approximately 0.09 percent of the total possible station operating hours. With the changes made or being made to the transmission facilities serving these stations, it is anticipated that in future years this figure will be reduced.

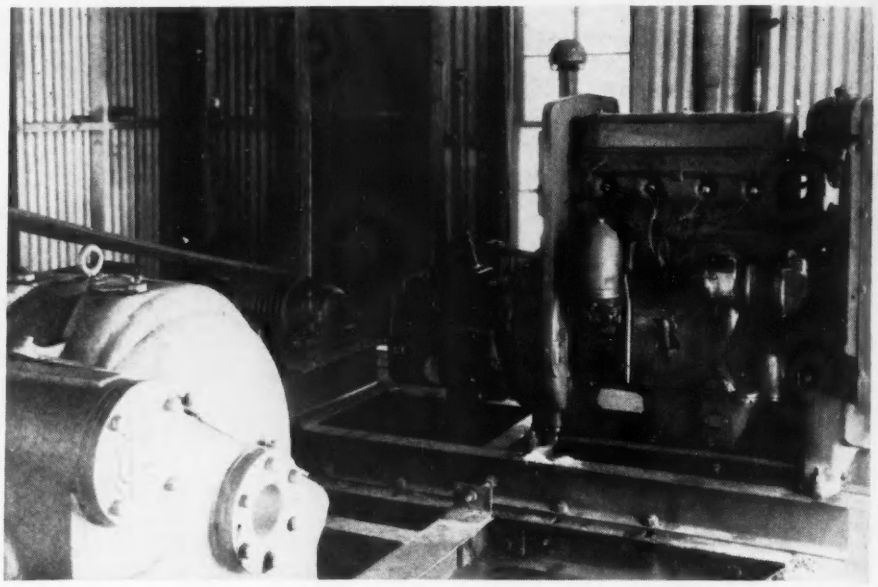
The company is at the present time proceeding with installation of standby, or emergency generators. At the reciprocating stations, the generators will be of sufficient size to allow for full operation of the station. At the centrifugal stations, the generators will furnish emergency light and enough power for the operation of the motorized valves.

As was pointed out earlier, the company was able to obtain the required power only with curtailment provisions in certain of our contracts for centrifugal stations. During the first ten months of 1949, curtailment was requested for 213 hours. This curtailment resulted in the loss of 4609 unit hours out of a possible 780,672 unit hours, or a loss of about 0.6 percent unit hours operation.

The loads are spread among 12 power companies from Texas to Pennsylvania, and range from 380 to 33,000 killowatts from each power company. These loads represent only fractions of some companies' total loads to 40 percent of one company's load. Without the utmost cooperation from all these power companies during a period of critical power shortage, the "Inch" lines today would not be transporting over 500 million cubic feet of natural gas per day to a fuel market where natural gas is practically the life blood of domestic consumers and many industries.

Another measurement term commonly used in the gas industry is MCF—a thousand cubic feet. Using this term, we find that about three kilowatt hours are needed to deliver one MCF from the Texas Eastern System. Considering that the Texas Eastern System has slightly over 3000 miles of 20-inch pipe or larger, one arrives at another factor of about 370,000 kilowatt hours used per year per mile of pipe. Recent figures show that more than 20,000 miles of large diameter pipe lines are either under construction, authorized, or planned. Applying the kilowatt hour per mile of pipe factor, which may or may not be representative, to the 20,000 miles of pipe lines, the potential use is 7400 million kilowatt hours.

The use of electrically driven centrifugal compressors in transporting natural gas through high pressure long distance pipe lines has now been demonstrated by actual operation. Future installations of electrically driven centrifugal compressors such as those of Texas Eastern Transmission Corporation will be decided largely by the cost of electric power.



Mounted on the flywheel housing, this gear is shifted into low to start the column of fluid moving through the ten-mile, four-inch line, and then shifted into high to bring pump up to speed to obtain rated throughput. Use of the gear box and clutch enables 40-horsepower engine to do well work which formerly taxed a 90-horsepower unit during the heavy starting cycle.

Gear Shift Starts *Cold Oil*

By ELMER WEAVER

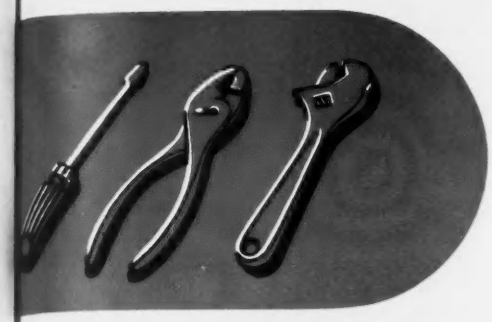
DIRECT-CONNECTED pumps, with bypass to relieve the power unit of the load for warming-up purposes, are customary in main line stations, and no relief other than throttling the stream of fluid from the pump is generally provided to take care of the starting load as against the usually lessened duty as the stream gets under way.

More Power Required

On a pipe line feeder station in the East Texas field area, the starting of a column of cold crude requires considerably more power than to keep it moving once the viscosity is improved by the stirring which the fluid is given as it reaches turbulent flow. A 90-horsepower engine was installed in this station, to handle fluid through a 10.5-mile line of four-inch pipe. During the hot summer months, flow was satisfactory, although there was considerable slipping of the clutch until the column of oil had been set into motion. During winter months, clutch life was a matter of weeks only, and pressures on the pump would rise to 500 pounds and then gradually drop to the normal figure of 200 pounds, gauge, to move 200 barrels per hour through the line.

Study of the setup showed that only 30 horsepower was required to drive the pump, once the oil was moving, although 90 was not sufficient to obtain desired flow at the outset. A 40-horsepower engine was set in to replace the larger unit first used, and a standard truck-type transmission installed. Instead of the conventional clutch pedal, a lever was mounted to the right of the gear shift lever, so that the gears could readily be shifted with the engine declutched.

With the new setup the engine was started, gears shifted into low, and the clutch let in. Under the reduced speed ratio, the 40-horsepower engine was able to start the oil slowly and without undue load on the clutch. As the oil began to move and to flow with speed enough to break the "set" which caused the high peak starting load, the gears were shifted into high and the full throughput of the pump attained.



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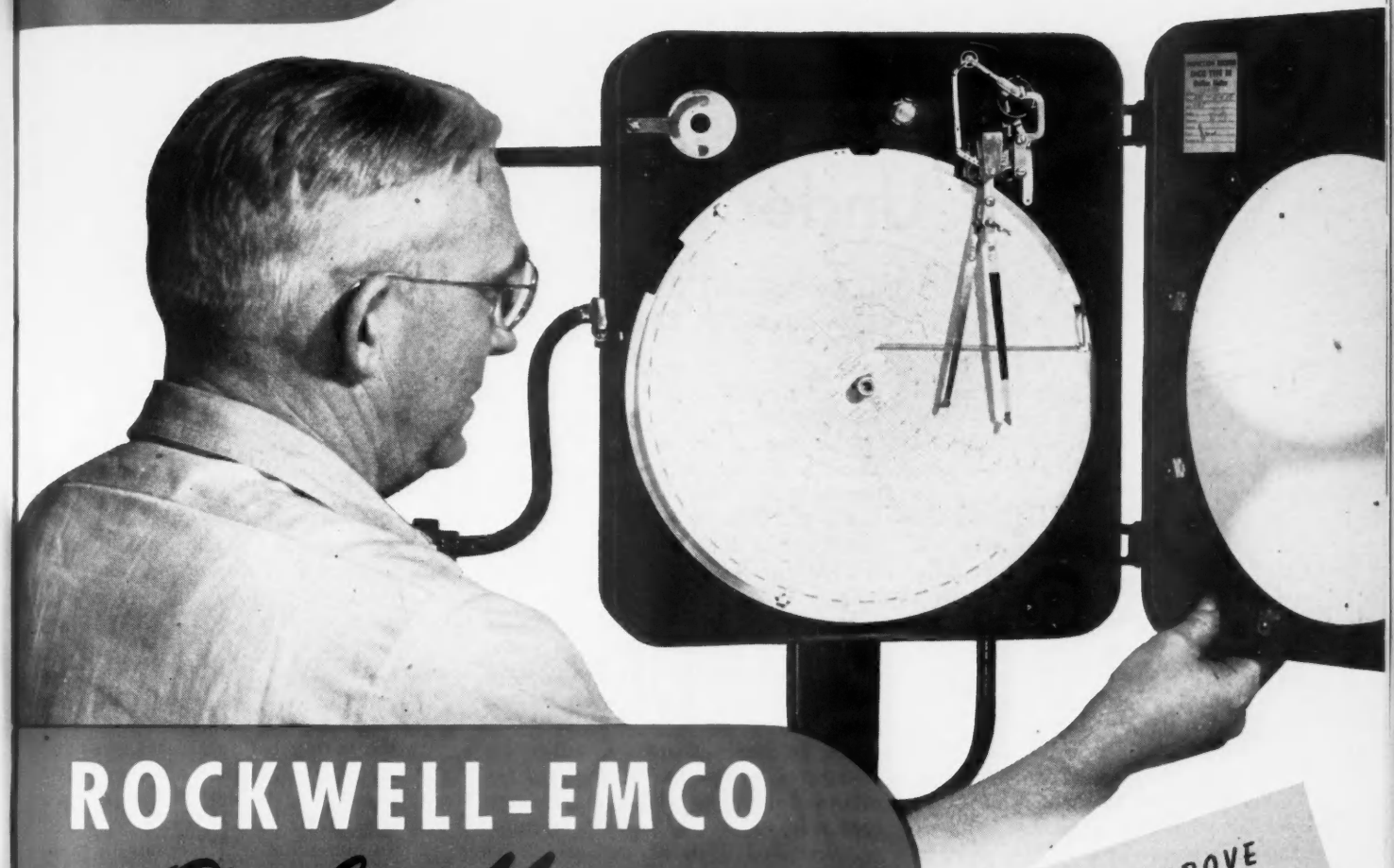

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CARE and MAINTENANCE

Tapping PIPE LINES Under Pressure

By ARTHUR M. HILL
Stanolind Pipe Line Company

MANY noteworthy improvements in tools and equipment within the last decade have provided safer working conditions and greater efficiency for the pipe line industry.

Examples of the improved tools are found in the modern pipe tapping machine. Although the tapping machine was conceived and developed more than 50 years ago, it was not widely used by pipe line companies until about 1935 with the development of a machine that made use of a special tapping nipple having internal threads to accommodate a special plug which is used to close the opening drilled into the pipe line. This permits removal or salvage of the gate valves used in conjunction with the tapping operations. These features greatly extended the use of tapping machines in pipe line operations and maintenance.

One tapping and plugging machine, also the tapping nipple and plug, were invented and designed by the author and J. E. Polston, a field superintendent for Stanolind Pipe Line Company. The original equipment was developed and built in 1932 in the shops of Stanolind Pipe Line Company, and a machine of improved design has been used exclusively throughout its system for the last 14 years in connection with the maintenance and repair of pipe lines and oil tanks. In recent years the author has engineered, designed, and developed two improved machines having an automatic feed mechanism. The current machines are described in detail, and are shown by photographs.

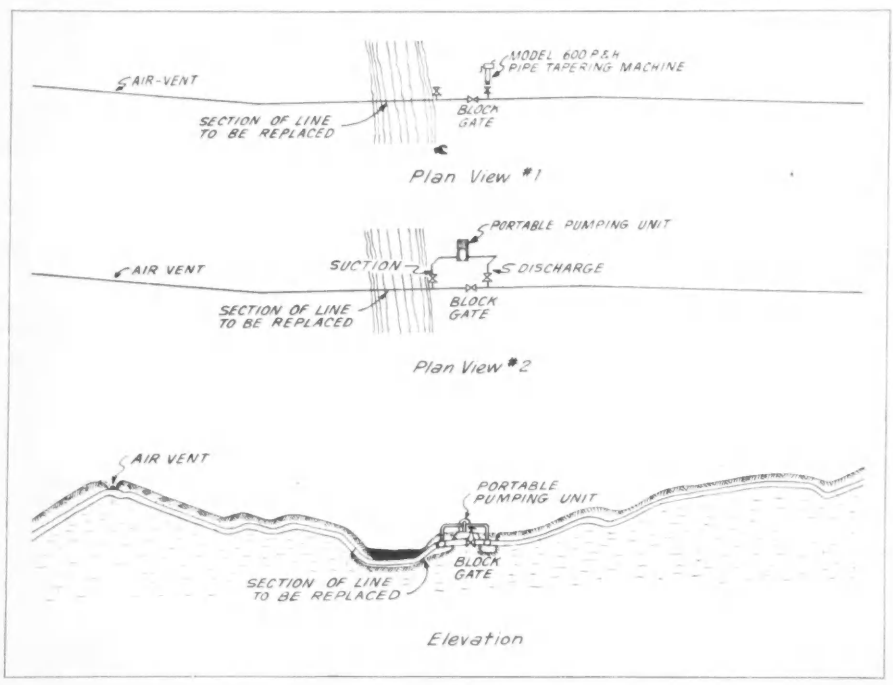

FIGURE 1

The objectives in the design and development of this machine were as follows:

1. To provide a machine suitable for tapping into oil pipe lines, products pipe lines, and natural gas pipe lines, at pressures up to 1000 pounds per square inch, with a substantial margin of safety to the workman.

This was accomplished by a frame composed of high strength steel castings and mechanical tubing assembled by arc welding, a heavy-duty packing gland, and a feed screw, synchronized with the boring bar that gives positive and safe control when advancing or withdrawing the boring bar when tapping lines under high pressure.

2. An automatic gear mechanism that feeds the cutting tool into the work in direct proportion to the ratio of the drive gears, and thus eliminates breakage of shell cutters. (This feature is essential in conjunction with the large size cutters.)

3. A compact machine having sufficient boring bar travel for tapping through large high pressure steel valves, and designed to accommodate the special plug used to close the openings drilled into the pipe line, thus one machine serves for both the drilling and plugging operations. This was accomplished by the telescopic principles used in the drive

TAPPING INTO A LINE under pressure, and filled with oil or gas, introduces a hazard which calls for thorough knowledge of existing line conditions if throughput and personnel are to be protected. The author cites precautions to be taken, and describes equipment for speeding the job.

tube, boring bar, and feed screw, also retainer shaft, which provides positive engagement when inserting or removing a special plug from the tapping nipple.

4. Machines in sizes most suitable for the various types of drilling and plugging operations are as follows:

A. Manual feed, for drilling and plugging openings from one to 3-7/16 inches, with boring bar travel of 22 inches. Weight of machine, 103 pounds.

B. Automatic feed, for drilling and plugging openings from 3-7/16 to 11½ inches, with boring bar travel of 36 inches. Weight of machine, 291 pounds.

Under development is a larger machine, which is being designed for drilling and plugging openings from 11½ to 22¾ inches in diameter, with boring bar travel up to 65 inches. Estimated weight, 600 pounds.

The development of this largest size machine has been requested by gas transmission companies for use in conjunction with tapping large diameter pipe lines.

Until recent years all tapping machines were operated with ratchet levers or hand cranks, and the cutting tool was fed manually as the cut through the pipe progressed. The hand feed mechanism has a tendency to overload the machine and failure of the cutting tool frequently occurs, resulting in delays and extra work, and sometimes disrupting pipe line operations. This trouble has been eliminated by the use of power driven machines with automatic feed, essential for the medium and large size cutters. The following describes some of the pipe line operations where tapping machines plan an important part:

In the maintenance and repair of large oil pipe line systems, and petroleum products pipe lines, it is frequently necessary to drain the oil from the lines for replacing sections of defective pipe in which leaks have developed due to soil corrosion, and from other causes. These pipe replacements are usually made at creek and river crossings, and low areas where corrosion is most severe and, in many instances, it is necessary to evacuate pipe lines to relocate sections of the line to conform with new highway construction, railroad improvements, and drainage canals. When new lines or pipe line loops are laid parallel with existing lines (to increase pumping capacities), certain sections of the pipe line system must be evacuated for connecting the new facilities. Portable pumping units are used for evacuating pipe lines, and tapping machines are used for drilling openings into pipe lines through special tapping nipples welded to the pipe line to provide a means of connecting the pumping units for transferring the oil or petroleum products into a parallel pipe line, or around a gate valve placed in the pipe line to facilitate draining.

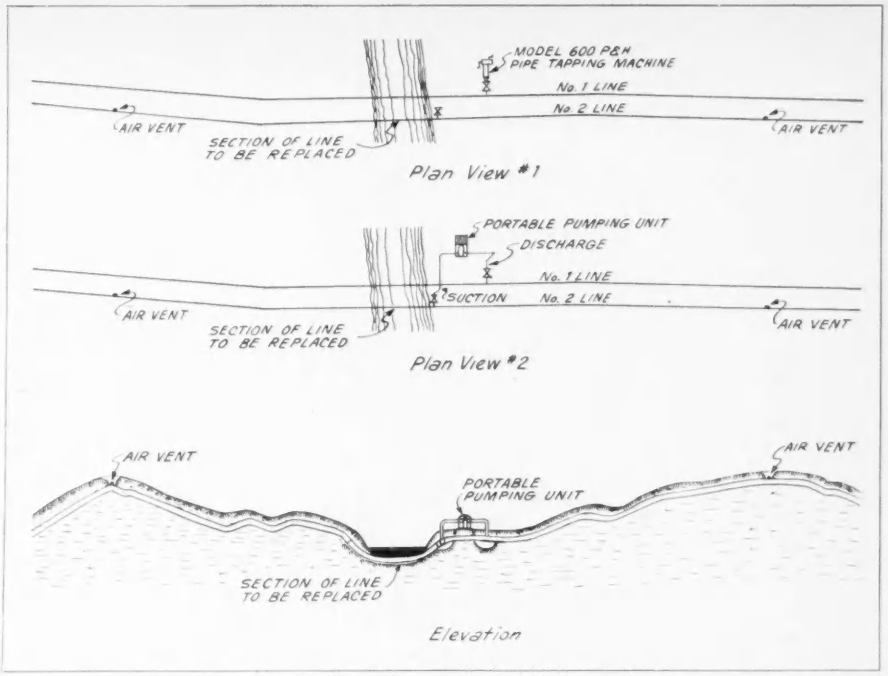

FIGURE 2

Transferring Method

Figure 1 shows a typical installation of a portable pumping unit as employed in the conventional method to empty a section of pipe line by transferring the oil into another line that lies parallel. The pumping unit is usually set at a location having a lower elevation than the section of pipe line to be drained, which assists the flow of the oil by gravitation toward the pumping unit. Preparatory to connecting the pumping unit a tapping nipple, either 3-, 4- or 6-inch (depending upon the size and capacity of the pumping unit), is arc-welded to the pipe line to be emptied. A similar tapping nipple is arc-welded to the parallel pipe line. A standard gate valve is installed on the tapping nipple and a tapping machine is then attached to the gate valve for drilling the openings into the pipe lines. The drilling operation requires from ten to 20 minutes, depending upon the size of the tapping nipple and wall thickness of the pipe line. With the improved machine the drilling operation may be performed while the pipe line is operating at pressures up to 1000 psi without the loss of fluid or pressure. After openings have been made in both tapping nipples, a suction line laid to the pumping unit is connected with the line to be emptied, and a discharge line from the unit is connected to the parallel pipe line.

In evacuating pipe lines with portable pumping units, or by other means, it is essential that air be admitted to the pipe line as the fluid is removed, otherwise the draining operation will not be complete. Also, it is very important that the evacuation be thorough (before cutting the pipe line and making preparations for tie-in welds), and any oil not transferred by the pump must be disposed of to prevent explosion and subsequent fire while welding is in progress. Due to the difference in ground elevations traversed by pipe lines, the draining operation can be greatly facilitated and more complete by tapping the pipe line at one or two high points to admit air which would release oil held in suspension by vacuum at the crest of hills. The small tapping machine shown in Figure 4 provides a convenient and economical means of tapping a line at the high points, also the larger taps up to 3-7/16 inches used for connecting pumping units.

After the pumping unit has been connected in the manner described above, and the air vents have been installed, the pipe line is taken out of service and pumping unit is operated to transfer the oil. After the line has been drained and work completed, the openings drilled in pipe line through the tapping nipple may be plugged with a special plug by use of the tapping machine. This permits removal of the gate valves used in conjunction with the pumping unit.

Within the last decade it has become the general practice by some pipe line companies to install block valves in pipe lines at strategic locations (during the construction period) for controlling drainage should breaks or leaks occur. The block valves provide a convenient

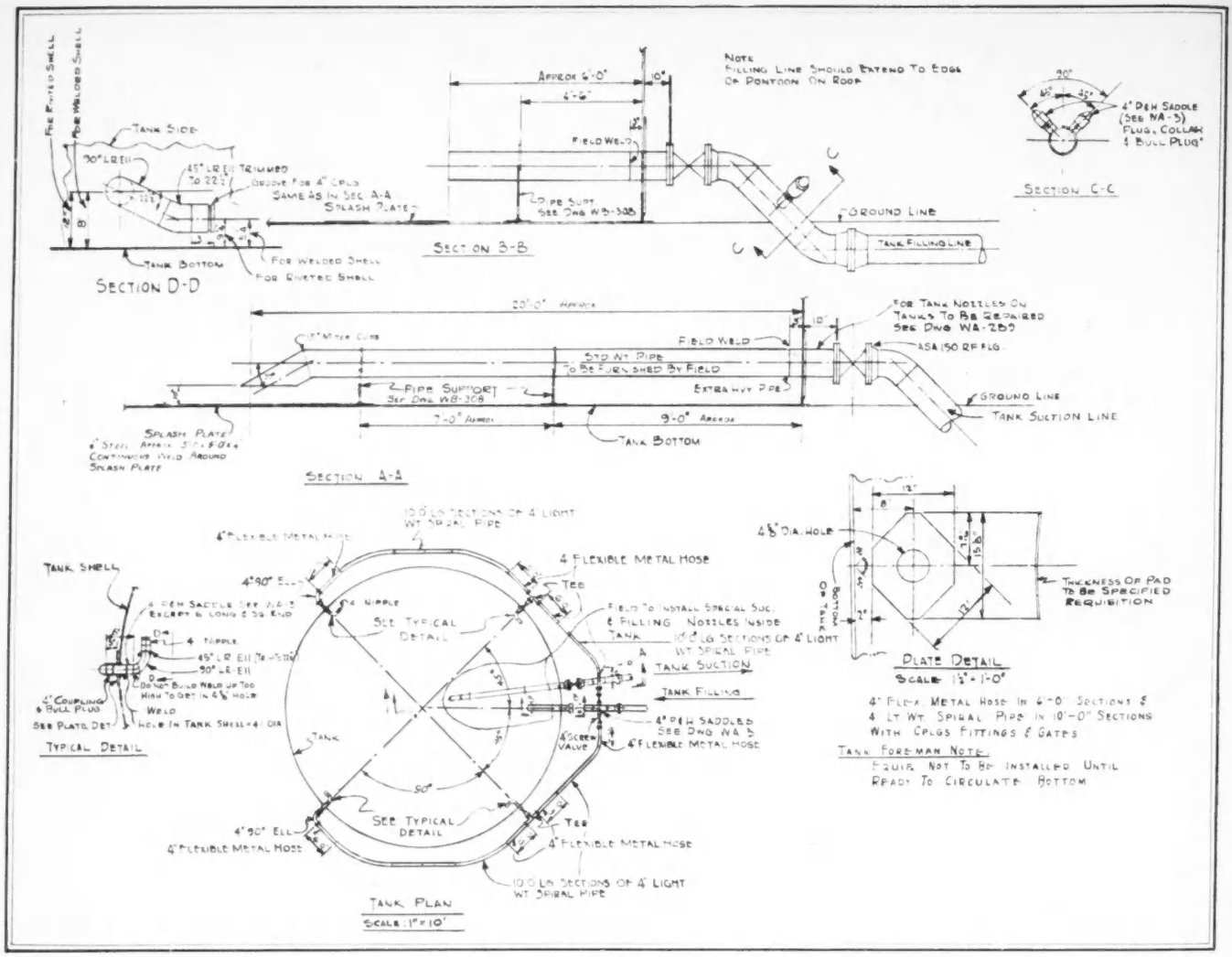

FIGURE 3

means of draining the line for repairs or changes in construction.

Figure 2 shows typical installation of a portable pumping unit connected with tapping nipples when used to drain a section of pipe line where no parallel line exists into which the fluid may be transferred. In this instance, the oil evacuated from the section of line to be repaired or relocated, is pumped into the other section of line around the closed block valve.

By use of the tapping nipple and tapping machine it is possible to make openings for connecting a pumping unit or other facilities at any location on a pipe line system; furthermore, tapping nipples are frequently installed on main trunk pipe lines and artery lines, for connecting field gathering lines. This type of connection can be made at a nominal cost, and eliminates the delay and expense of draining the artery line. Tapping nipples and tapping machines are used advantageously for connecting certain facilities at pipe line pump stations.

Figure 5 shows the automatic feed tapping machine in operation at a trunk line manifold where piping alterations are being made to connect new tanks.

Until recent years it has been the usual practice to remove bottom sediment and water from oil storage tanks by the conventional hand method at a cost of about $1 per barrel, and the bs&w then disposed of by burning. With a new procedure recently developed by one large pipe line company,

CONTINUED ON PAGE 184

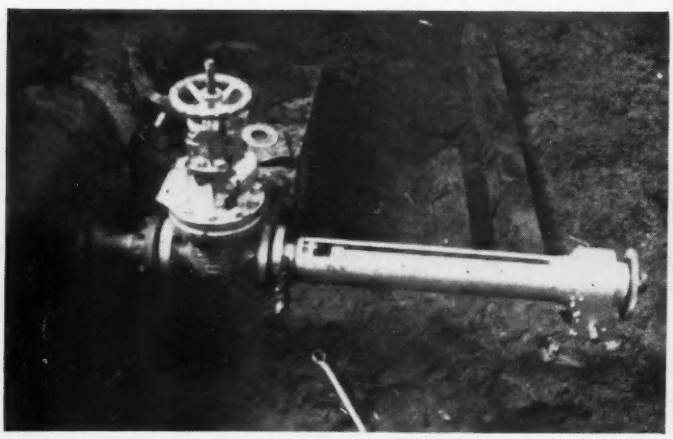

FIGURE 4

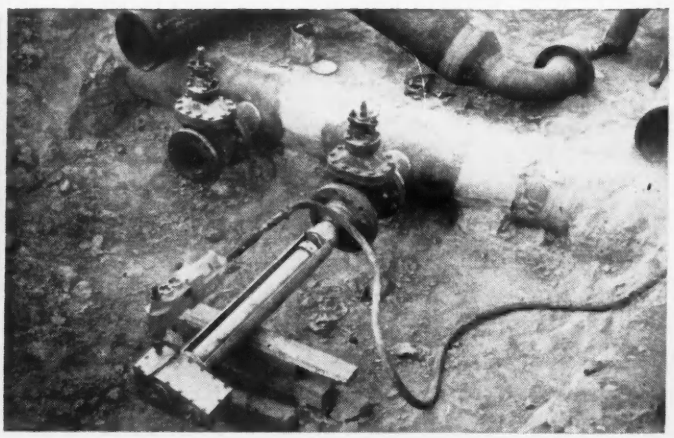

FIGURE 5

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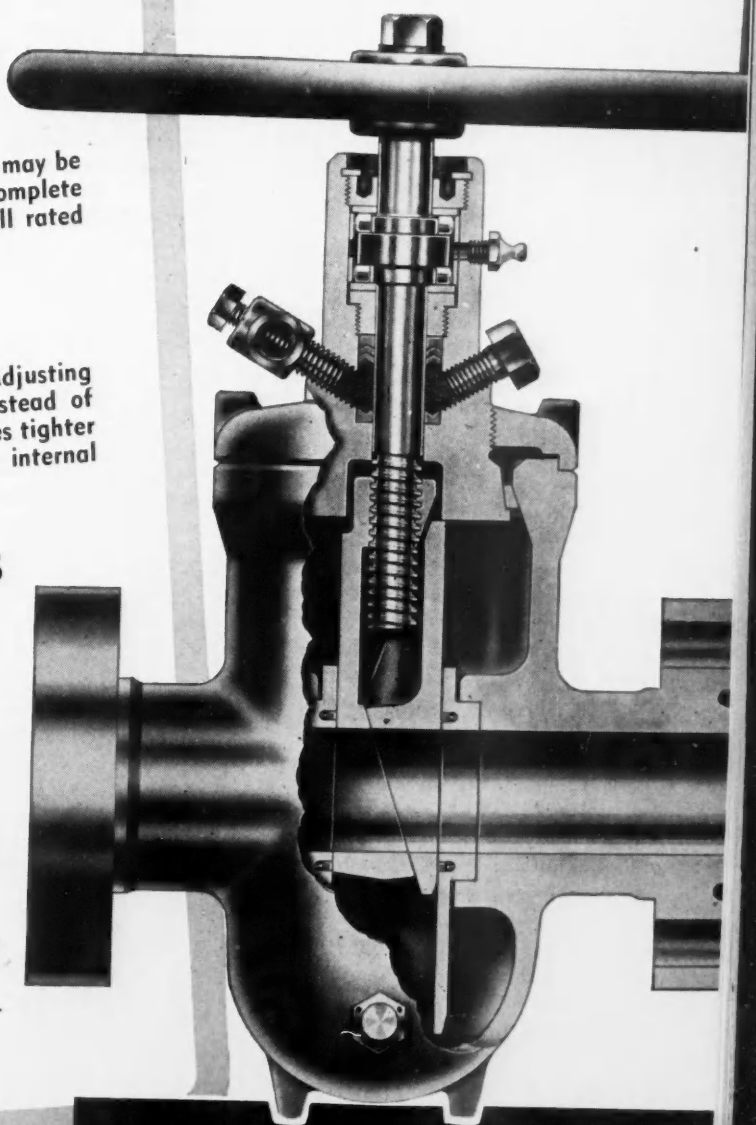

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DUAL FUEL

Engine Development

By L. W. CRUMP
Chief Industrial Engineer, Oklahoma Natural Gas Company

SUCCESSFUL development of the dual fuel-type diesel engine which has occupied engineers in the last few years opens to the pipe line and drilling industries the possibilities for a prime mover which can result in convenience, economy, and greater efficiency.

The growth in the use of dual fuel diesel engines since the first plant of this type was put into operation about 3½ years ago has been phenomenal. In November, 1945, a 225-horsepower solid ejection four-cycle atmospheric diesel engine was converted to dual fuel and placed in operation in El Reno, Okla. This original installation was very crude compared to the present day equipment available for operation on dual fuel principles, but it was the start in Oklahoma of this type equipment. This original conversion unit is still operating 24 hours a day, producing electric power on a total fuel rate of less than 12,000 British thermal units per kilowatt hour. Of the total fuel input, approximately 12 percent is fuel oil and 88 percent is natural gas, at an average load factor of about 75 percent. Several refinements have been added to this engine to smooth out the operation and make it automatic in changing over from gas diesel to diesel oil in the event of shortage of gas. The overtravel of the governor was used to make this change.

The use of gas in a diesel engine has generated some new terms which should be defined. A dual fuel engine is an engine which can be operated on either 100 percent fuel oil or a combination of fuel oil and gas and can be changed from one fuel to another either automatically or manually without interfering with the operation of the engine or its load. For normal operation, a dual fuel engine will use a fixed amount of pilot oil regardless of the load on the engine, the varying load on the engine being handled by the governor increasing or decreasing the amount of gas supplied. Likewise, if the amount of gas available is limited, an increase in load can be supplied by the governor increasing the amount of fuel oil injected.

THE AUTHOR presents some of the advantages gained through adaptation of diesel engines to use of dual fuel where natural gas is available. Not only are better operation characteristics possible, but the change-over also lengthens time between overhauls and reduces maintenance.

A gas diesel engine, although an engine which can be operated either as a 100 percent fuel oil engine or as a combination of gas and fuel oil, as already indicated, requires changes in equipment in changing from one fuel to another which necessitate shutting down the engine. In most cases, the change necessary is that of replacing small nozzles used in the gas and fuel oil combination with large nozzles required for fuel diesel oil operation. A gas diesel engine generally has a fixed ratio of pilot oil and gas.

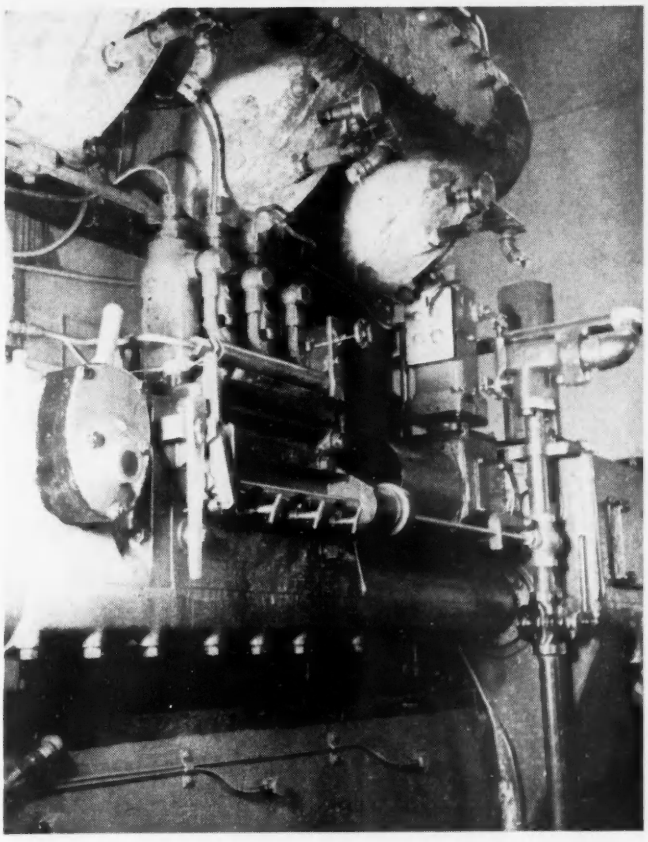
The atmospheric dual fuel or gas diesel engine will generally operate on fairly low pressure gas. The flow of gas to the individual cylinders is continuous, accumulating in the intake valve passage, and is drawn into the cylinder with the air during the period when the intake valve is open.

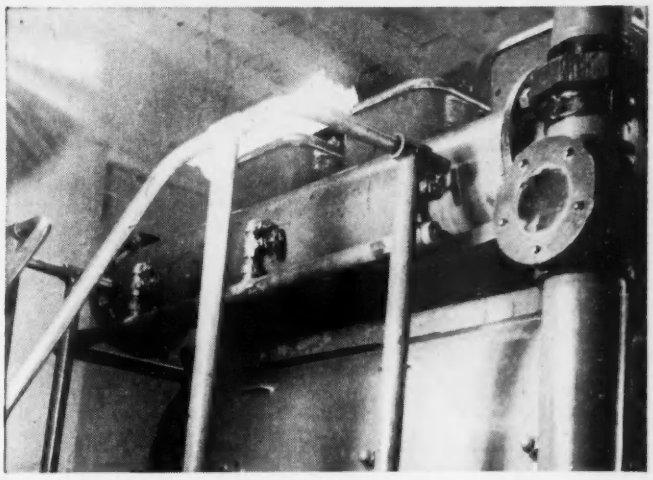
Thus a dual fuel engine is automatic in changing from one fuel to another and may be operated on almost any percentage of either fuel between maximum and minimum limits while a gas diesel operated on a fixed amounnt of pilot oil, making up the balance of the fuel requirements with gas, cannot be automatically changed from one type fuel to the other.

With the increased use of supercharged diesel engines for stationary installations, the conversion of this equipment to dual fuel became important economically. There are now a number of large dual fuel diesel engines of the supercharged type in operation in Oklahoma. The conversion of a supercharged four-cycle engine is quite a different proposition from that of a standard atmospheric engine. The principal difference is the necessity of timing the period of gas injection in order to eliminate fuel waste during the portion of the scavenging stroke when both intake and exhaust valves are open. This required mechanically operated gas injection valves and increasing the gas pressure delivered to the governing valve to permit the required volume of gas to be injected through a short portion of the compression stroke.

Supercharged engines operating on pipe line duty where the load is fairly constant and approaches the full rating of the engine, can obtain good fuel economy without the necessity of controlling the volume of supercharged air supplied to the engine. However, for power plant use, where the load is constantly changing, it is necessary that the supercharged air also be throttled in order to maintain high fuel efficiency over a range of load. When the volume of supercharged air is controlled, it becomes necessary that the timing of the pilot oil injection be varied in order to maintain good performance. Engines with these refinements are producing electricity at a fuel rate in the neighborhood of 11,000 Btu's per kilowatt hour with the pilot oil averaging as low as seven percent on an average load factor of only 52 percent.

A manufacturer of two-cycle engines is now producing two-cycle dual fuel engines. The city-owned electric generating plant at Yale, Okla., has installed one of these units. This same manufacturer has arranged to convert four large atmospheric two-cycle diesel engines to





ABOVE: Intake side of engine showing gas piping to individual cylinders.

LEFT: Showing gas piping to engine and governor control valve on gas line.

dual fuel in the power plant at Yukon, Okla. This conversion work is now in progress.

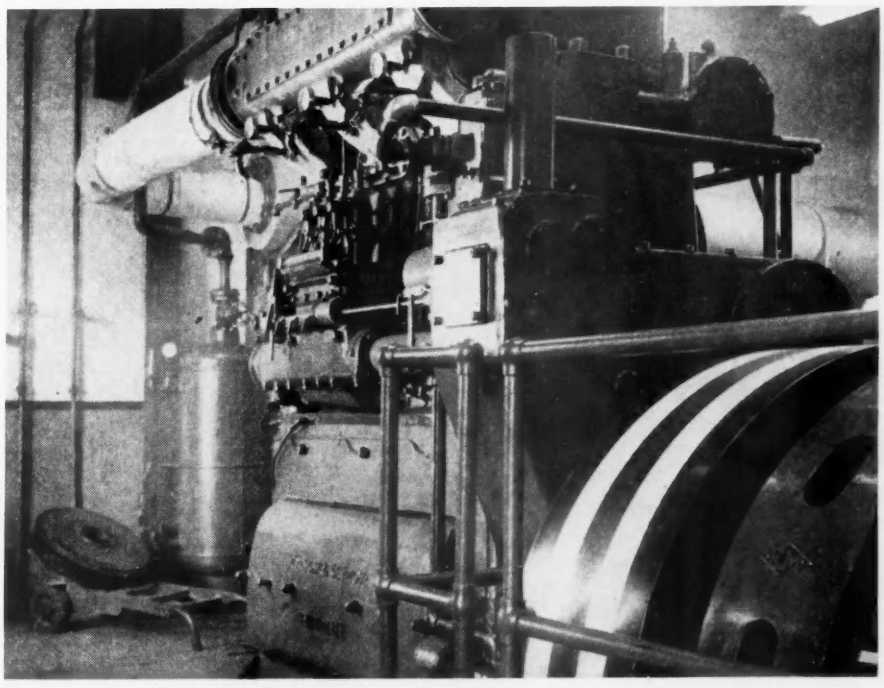
Practically all manufacturers of four-cycle diesel engines are now in a position to make conversion of their equipment in the field. Some of the recent conversions of this nature have been units in the city-owned light plants at Pawnee, Perry, and Cushing. One of the largest city-owned light plant installations of gas diesel engines is that of Ponca City, which is now operating in excess of 8000 horsepower of gas diesel engines. These engines use high pressure gas, which is injected along with the pilot oil at the top of the compression stroke.

To the best of our knowledge, no one has yet converted a crank-case scavenging two-cycle diesel engine to dual fuel operation. When a practical and economical method of converting that type engine to dual fuel operation is developed, it will open this type of operation to many thousands of horsepower of diesel engines.

Many of the large pipe line companies operating in the state of Oklahoma are using air injection diesel engines. Since a manner is presently available to convert these engines to dual fuel, it is anticipated that a number of the installations located near a supply of natural gas will be so converted.

The value of dual fuel operation of diesel engines to operators of this equipment is tremendous. One of the city-owned light plants that has recently converted four engines from atmospheric diesel to atmospheric dual fuel has estimated its savings at approximately $80 a day from fuel alone. One of the characteristics of a dual fuel engine is a lower exhaust temperature than that of the same engine operating as a fuel diesel. The large volume of gaseous fuel compared to the small volume of vaporized liquid fuel results in a more complete burning within the cylinder and less carbon is produced. This is definitely proved by long operation of oil filters on a dual fuel engine compared with a full diesel engine.

The distinct advantage to the operator of a dual fuel engine is that he may take advantage of the lowest fuel cost. If gas is available at a Btu cost less than that



End of engine showing pipe from governing valve to intake side of engine.

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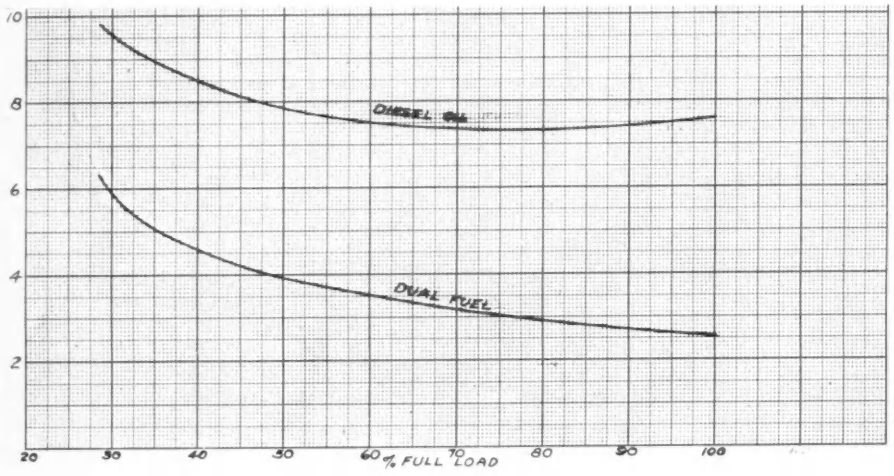
of diesel oil, he can operate on gas with a minimum of pilot oil. If diesel oil is less costly per Btu than gas, he can operate on diesel oil alone. If the volume of gas available is insufficient for full operation as a gas diesel, but presents a price advantage, he can use all available and make up the rest with oil.

For drilling operators dual fuel equipment permits the operator to use diesel oil if gas is not available and to take advantage of natural gas in areas where it is available for use.

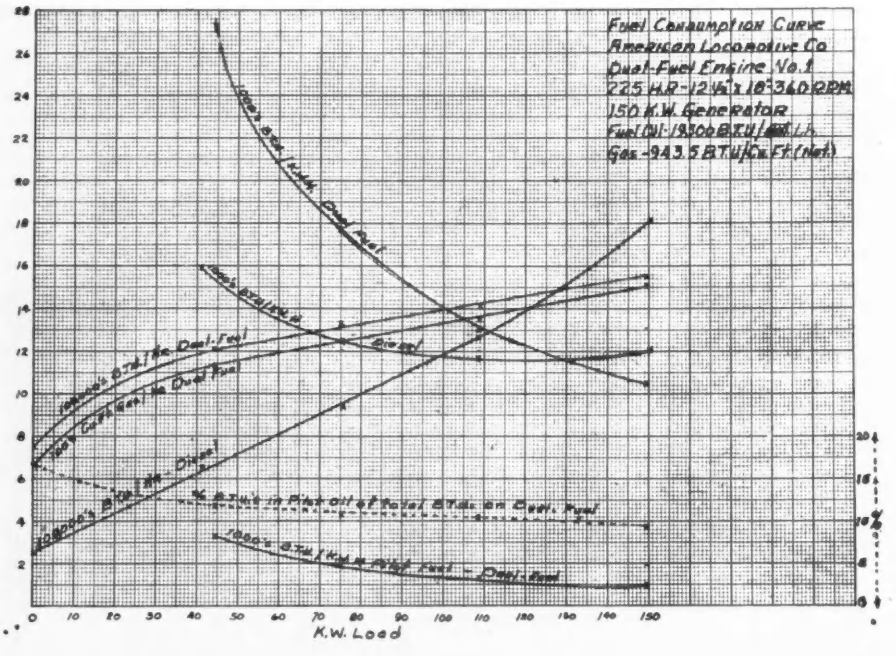
In plants where continuous operation is necessary, and a gas line failure of any nature would prove costly, a dual fuel engine can be installed and equipped to change over automatically to full diesel operation in case of such gas failure.

One of the most interesting features of dual fuel engine operation is that the total Btu consumption at loads in the vicinity of rated load of the engine is almost always less as a gas diesel than it is for full oil operation. If the load drops off to the point where the fuel consumption as a gas diesel would make full oil operation more attractive, the governing equipment can be adjusted so that the engine will automatically change to full diesel at this point and also will return to gas and oil operation when the load exceeds this amount.

Today there is hardly a manufacturer of diesel engine equipment that is unable to provide his engines for dual fuel or gas diesel operation, as well as full diesel oil operation. This is significant as it shows the increasing demand for dual fuel engines and this type of equipment should result in greater efficiency and economy to pipe line and drilling rig operators, as well as in other industries where there is an adequate supply of natural gas available.



Fuel cost per kwh:
Gas—20 cents/mcf, 1000 Btu/cubic foot. Oil—9 cents/gal., 143,000 Btu/gal.
10 percent oil at full load.



Tapping Pipe Lines

CONTINUED FROM PAGE 178

it is possible to reduce the accumulations of bs&w by injecting fresh crude into the bottom of the tank through a circulating system. This consists of arc welding four tapping nipples to the tank shell at 90-degree intervals around the circumference of the tank, and a few inches above the tank bottom. The tapping machine is then employed to drill openings through the tank shell preparatory to installing piping for circulating the oil stream.

Figure 3 shows a typical piping layout as employed in the circulating system. With this procedure the tank filling valve is closed and the incoming stream is distributed through the temporary piping system to the four connections equally spaced around the circumference of the tank. The force of the stream entering the tank creates a jetting action, which is sufficient to break up the bs&w and cause it to flow toward the suction line, and thence to the pumping unit where it becomes a part of the oil stream in transit. By this method a quantity of 5000 to 6000 barrels of bs&w may be removed from the tank in a period of six to 10 days. After the bs&w is reduced to a minimum, the circulating system is disconnected and the tapping nipples are closed with special plugs.

This method of tank cleaning has many advantages and effects substantial savings in labor and expense, as compared with taking the tank out of service for removing the bs&w.

Experience has shown that the circulating system is most effective in the summer when atmospheric temperatures are highest. This method is particularly adaptable for use on new and reconditioned tanks, and if employed once a year bs&w accumulations can be kept to a minimum. This method is simple and may be installed at a nominal cost.

The estimated cost of installing the circulating system on an oil storage tank is as follows:

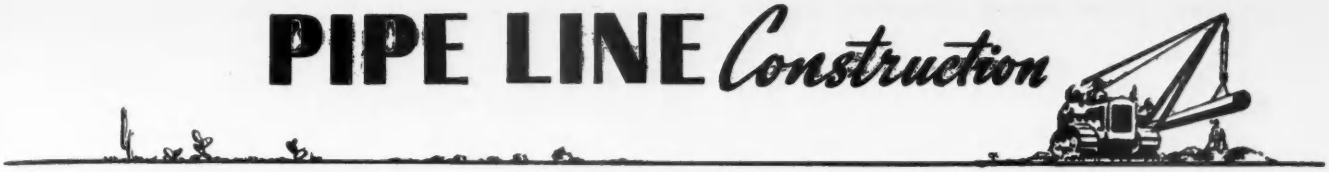
Install 4 tapping nipples at 90° intervals around the tank:	
Material	$250
Labor	200

Following is the estimated cost of fabricating and installing piping for the circulating system:

Valves, connections, and piping	$850
Labor to connect and disconnect	250

Since the circulating piping is temporarily connected with the tank it may be removed for use on other tanks where a circulating system may be employed. Cost of this piping should be divided by the number of tanks on which it may be used.

PIPE LINE *Construction*



By CECIL W. SMITH
Statistical Editor

THE first major pipe line construction project proposed in 1950 was a $32,520,000 expansion program announced by the Southern Natural Gas Company when it made application to the FPC early in January. Southern Natural asked permission to increase its system's capacity 109 million cubic feet a day by laying 803 miles of new pipe line and installing 19,200 horsepower in compressor stations.

A total of 496 miles of 16- and 18-inch main transmission line would be laid between the Gwinville gas field in Mississippi and Aiken, S. C., by way of Columbus and Augusta, Ga. In addition, the proposal calls for the installation of 307 miles of various size pipe as loops along the present system, which originates in the Carthage gas field of Eastern Texas, and marketing connections to 38 communities in Alabama, Mississippi, Georgia, and South Carolina.

The new lines are designed to increase the system's present daily capacity of 420 million cubic feet by 26 percent, resulting in a daily throughput of 529 million. If FPC permission is granted soon enough and adequate materials are available, the major portion of these new gas facilities will be completed before the winter of 1950-1951.

Before 1950 ends, large-scale gas deliveries will be made to the New York City area as Transcontinental Gas Pipe Line Corporation completes its giant 1840-mile transmission line. This gas project, largest ever undertaken, is to be completed by November 1. During 1949, about 600 miles of line were laid between Louisiana and Georgia, and contracts will cover 707 miles to extend the system to New York.

Contracts for the more than 500 miles that will extend the line southwesterly to the Texas Rio Grande Valley will be let soon and work on that segment will start early this year.

Pipe Line Construction

Table includes projects planned, contracts awarded, and spreads or entire projects completed since the last issue of WORLD OIL

COMPANY	Origin and Terminus	Length, (Miles)	Pipe Size, (Inches)	Daily Capacity (Barrels, Cu. Ft.)	REMARKS
CRUDE OIL LINES					
Corporaccion de Fomento de la Produccion (Chilean Government,	Cerro Manantiales fld. (Springhill) to Bahia Gente Grande, Chile	42½	8	10,000	Line completed late in 1949 by Chilean personnel under supervision of North American technicians.
Yacimientos Petroliferos Fiscales	Tupungato and Agrelo to Lujan de Cuyo refinery, Argentina	35	.....	.....	Now being planned for 1950 construction.
Humble Pipe Line Company	Kemper to Eckert, Texas	178	18	135,000	Morrison Constr. Co., Inc., Austin, started this section in December.
	Eckert to Satsuma, Upper Texas Coast	193	18	135,000	Anderson Bros. Corp., Houston, will start laying this section after pipe is yard coated and wrapped. Probably in March.
Magnolia Pipe Line Company	Pegasus fld., Midland-Upton Co. to Midland, W. Texas.	25	8	25,000	Line and gathering system completed in Dec. by C. L. Rogers Constr. Co., Inc., Wichita Falls, Texas.
	Gathering system in Pegasus fld., West Texas	6	4 & 6	.....	
Mid-Valley Pipeline Company	Mississippi River Crossing north of Lake Providence, La.	1	20	.....	Crossing of two 20-inch lines completed in Dec. Pipe work done by Latex Constr. Co., Houston, and dredging by McWilliams Dredging Co., New Orleans.
Richfield Oil Corporation	Cuyama Valley fld. to Newhall, California	40	10	.....	Planned.
PRODUCT LINE					
Great Lakes Pipe Line Company	Tulsa, Okla. to near Kansas City, Missouri	236	12	.....	Part of a 1141-mi parallel line project. Pacific Pipe Line and Engineers, Ltd., Los Angeles, started with 4 spreads early in January, and except to complete in March.
	Ponca City to Barnsdall, Oklahoma	54	12	.....	Contract awarded to A. C. Holder Constr. Co., Tulsa. To start in January.
NATURAL GAS LINES					
Cities Service Gas Company	Wichita to Newton, Kansas	29	16	.....	Yet to be contracted.
Direccion General del Gas del Estado.	Caleta Olivia to Comodoro Rivadavia, Argentina	62	.....	.....	Planned for 1950 construction and will connect to 1055-mile Buenos Aires line at its southern terminus.
Harrisburg Gas Company	Maytown to Harrisburg, Pennsylvania	16	8	.....	Application made to FPC. Line would supply Harrisburg from Manufacturers Light and Heat's system near Maytown.
Houston Pipe Line Company	Crosby to Baytown, Upper Texas Coast	14	12	.....	L. E. Farley, Inc., Houston, started in Dec. Line will tie into Houston's 18-in main at Baytown.
Michigan Consolidated Gas Co.	Austin storage fld. to Reed City storage fld., Michigan	21	24	.....	Plans call for additional 9600 hp in Austin compressor sta., with dehydration & metering at Reed City.
Michigan-Wisconsin Gas Company & Michigan Consolidated Gas Company.	Installation of additional compressors on Tex.-Mich. line	..	.....	.....	Applied jointly to FPC for addit on of 115,500 hp on newly completed line, which would raise capacity from 155 mln to 303 mln daily.
Mississippi River Fuel Corporation.	Loops between Perryville, La. and St. Louis, Missouri	219	24	130 mln	Completed in Dec. by R. B. Potashnich, Cape Girardeau, Mo. Loops now form continuous second line to St. Louis. Stations at Perryville and West Point, Ark. were built by Refinery Maintenance Co., Compton, Cal.

▪ TABLE CONTINUED ON NEXT PAGE

Table includes projects planned, contracts awarded, and spreads or entire projects completed since the last issue of WORLD OIL (CONTINUED)

COMPANY	Origin and Terminus	Length, (Miles)	Pipe Size, (Inches)	Daily Capacity (Barrels, Cu. Ft.)	REMARKS
Northern Natural Gas Company	Loop 1. North of Skellytown in Pampa, Texas area	40 3/10	26	130 mln	Contracts let for 597-mile 20 & 26-inch looping project, designed to increase daily capacity of Texas-to-Minnesota line from 470 mln. to 600 mln. Project is still subject to FPC approval. 40,000 hp would be added in 7 old stations and 2 new Kans. sta. R. H. Fulton & Co., Lubbock, Tex., will build Loops 1 thru 5.
	Loop 2. North of Beaver, Oklahoma	74 9/10	26	.....	
	Loop 3. Mullinville, Kansas area	33 1/4	26	.....	
	Loop 4. Bushton, Kansas area	72 1/2	26	.....	
	Loop 5. Garden City to Bushton, Kansas	155	20	.....	
	Loop 6. Between Palmyra, Neb. and Oakland, Iowa	43 4/10	26	.....	Midwestern Constructors, Inc., Tulsa, has contract for Loops 6 & 7.
	Loop 7. Northeastward from Oakland	65 9/10	26	.....	
	Loop 8. Southwest from Ventura, Iowa	31 3/10	26	.....	
	Loop 9. Northward from Ventura, Iowa	41	26	.....	Contracts for Loops 8, 9, 10 awarded to R. B. Potashnick.
	Loop 10. Starts 26 miles from north end of Loop 9	39 1/2	26	.....	
	Sublette, Kansas to Oklahoma Panhandle	23 7/10	20 & 24	.....	Scheduled for end of January completion by R. H. Fulton & Co. Will connect with Plains Nat. Gas' system in Hugoton fld.
Plains Natural Gas Company	Gathering system in Hugoton fld., Okla. Panhandle	78	4 to 24	.....	Arey-Phillips Constr. Co., Dumas, Texas started in Jan. and will complete by end of March. First part of new 282-mi system. Other contracts to be awarded.
Southern Natural Gas Company	Gwinville fld., Mississippi to Aiken, South Carolina	496	.....	109 mln	Application made to FPC for 803 miles & 19,200 hp to increase system capacity 109 mln to 529 mln. Project would cost $32,520,000.
	Loops & connections in Texas, La., Miss., Ga., & S.C.	307	.....	.....	
Stanolind Oil & Gas Company	Chocolate Bayou & Rowan flds. to Hastings Plant, Upper Texas Coast.	16	6	.....	Completed in Dec. by W. L. Golighly Constr. Co., Houston
Texas-Empire Pipe Line Company	Loop between Wilmington and Chicago	42	16	.....	Awarded to O. R. Burden Constr. Corp., Tulsa.
Texas Gas Transmission Company	Louisville to Lebanon, Ohio	80	26	.....	Spread 10 of Texas-to-Ohio transmission line completed end of 1949 by Midwestern Constructors, Inc.
Transcontinental Gas Pipe Line Corporation.	Sect. 4 & 5 Demopolis, Ala. to Newnan, Georgia	216	30	340 mln	To be completed Feb. 1, by Midwestern Constructors, Inc.
	Sect. 7 Danielsville, Ga. to Spartanburg, S.C.	86	30	.....	Contracts for construction north of Georgia on Texas-New York line recently let. Williams Bros. Corp., Tulsa, awarded Sect. 7.
	Sect. 8 Spartanburg to Catawaba River, N.C.	102	30	.....	R. H. Fulton & Co. will lay both Sections 8 & 9. Work will probably get underway in January.
	Sect. 9 Catawaba River to Spray, N.C.	100	30	.....	
	Sect. 10 Spray, N. C. to James River, Va.	86	30	.....	Contracts for Sects. 10 & 11 awarded to O. R. Smith Contracting Corp., Ft. Worth.
	Sect. 11 James River to Potomac River, Va.	110	30	.....	
	Sect. 12 Potomac River to Sesquehanna River, Pa.	76	30	.....	Associated P. L. Contractors, Inc., Houston, will start in May.
	Sect. 13 Susquehanna River to Delaware River, Pa.	90	30	.....	Wunderlich & Griffis P. L. Constr. Co. Co., Tulsa, awarded Sects. 13 & 14 and will begin work in April.
	Sect. 14 Delaware River to near Linden, N. J.	61	30	.....	
	Sect. (Unnumbered) Linden to Hudson River, N.J.	23	26 & 30	.....	Oklahoma Contracting Co., Inc., Dallas, started in Dec.
Westock Gas Company	Edmond, Oklahoma vicinity	14	12	.....	Completed in Dec. by B. H. Walker Constr. Co., Oklahoma City.

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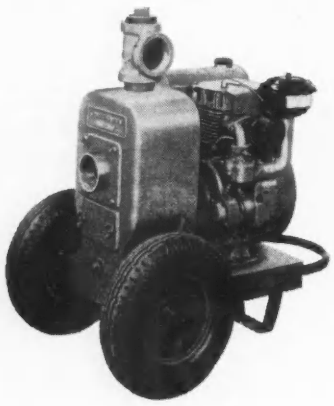

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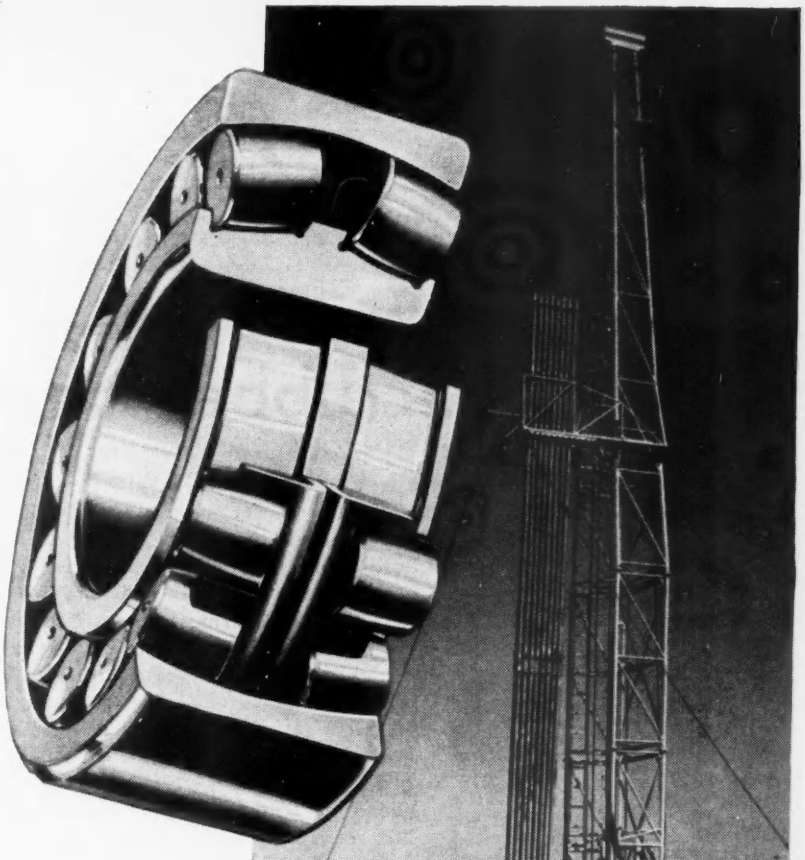

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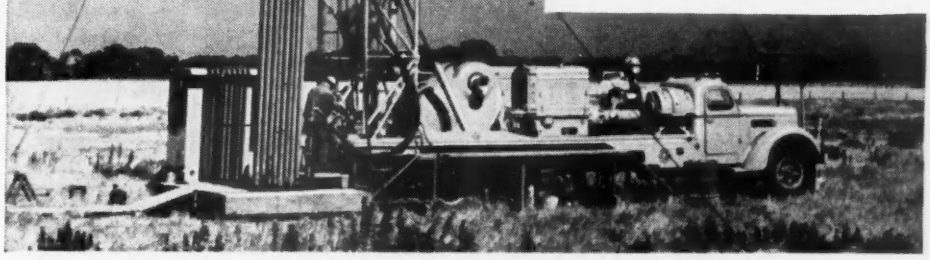

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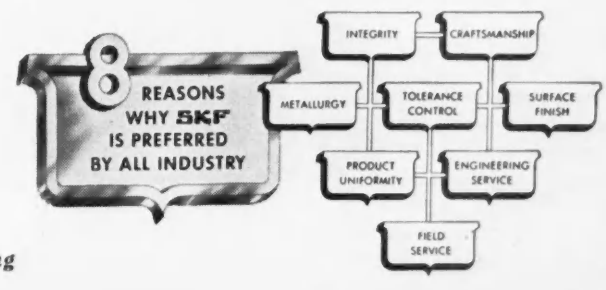
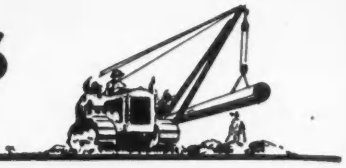


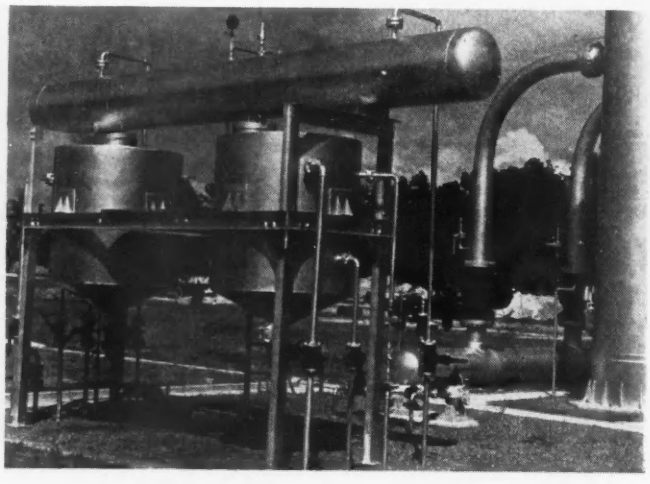
How to do it!

PIPE LINE HINTS



$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

HOW TO—Add Make-Up Oil to Scrubber Unit



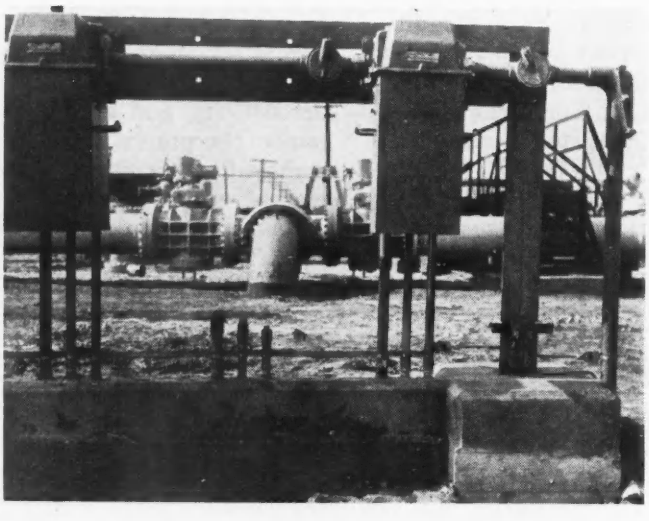
Adding make-up oil to a gas scrubber unit at a compressor station can be accomplished under pressure with an elevated horizontal tank. It is not necessary to close the scrubber and bleed the pressure down to add oil. The fabricated equipment illustrated performs this operation quickly and safely.

Supply of make-up oil is stored in two large-capacity cylinders supported by a structural steel framework. Both vessels are open to the atmosphere at the top, and are coned at the bottom where a cleanout valve has been added. The make-up oil is supplied by a connection near the top edge. Oil is removed by a 1½-inch line from each vessel at a point about ten inches from the lower edge.

Surmounting the structural support is a long pressure cylinder. Make-up oil is pumped from the storage vessels by a gas-powered centrifugal pump. Input lines to the cylinder are closed and gas pressure from the scrubber is introduced by a small equalizing line connected at the top and near the center of the horizontal tank. With pressure in the scrubber and the horizontal vessel equalized, oil in the latter will flow into the scrubber by gravity, due to its elevated position. When the needed oil has been added, the feed line is closed off and the unit made ready for another operation.

A small line connecting the bottom of the scrubbers with the large storage vessels contains a small constricting line fitted with a needle valve. If too much oil is added to the scrubber, it can be fed back to the storage vessel through this constricted line which provides the pressure drop and regulation. Sediments and water can be drained off at the bottom by a drain plug.

HOW TO—Drain Stray Current From Conduit



Since dry concrete is in itself a fair insulator, one pipe line company does not rely on the foundations for its control equipment to carry away any stray currents which may occur in the conduiting which carries the circuits to the various control and instrument panels.

Before the installation is painted, and even before all the controls are set in place, a wide band of perforated copper is carried along the entire setup, a few inches above the top of the concrete foundation. At each conduit and on the vertical members of the steel supporting frame a firm electrical contact is established through a ground clamp with metal-to-metal contact through any paint which may have been put on the equipment previously.

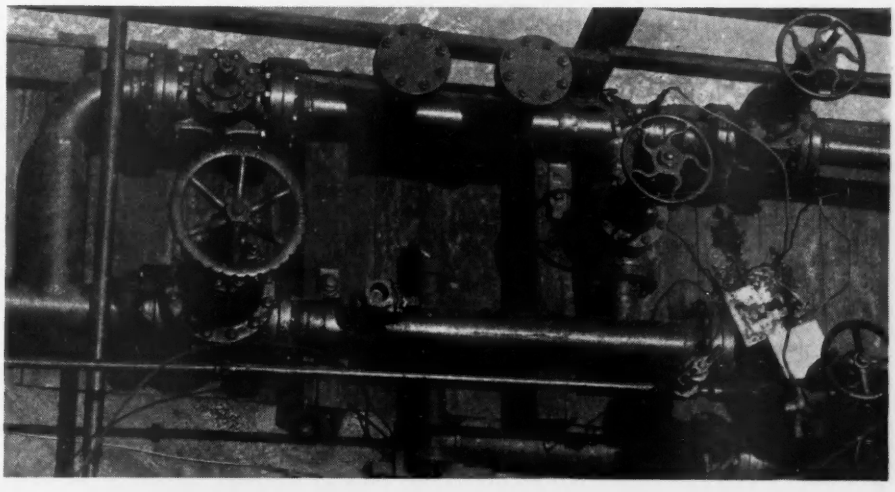
The ends of the continuous ground strip are attached to ground rods, driven into the earth outside the foundation line, and carried to permanently moist soil.

With such a ground system a drain path is provided for any currents which may be set up in any of the conduit systems to the various drives, and any possible electrolytic effect thus eliminated before it can cause corrosion. The ground is heavy enough to drain off a short, as well as to carry stray currents, and is protected against accidental damage through the support afforded at each ground clamp to conduits carried in the concrete.

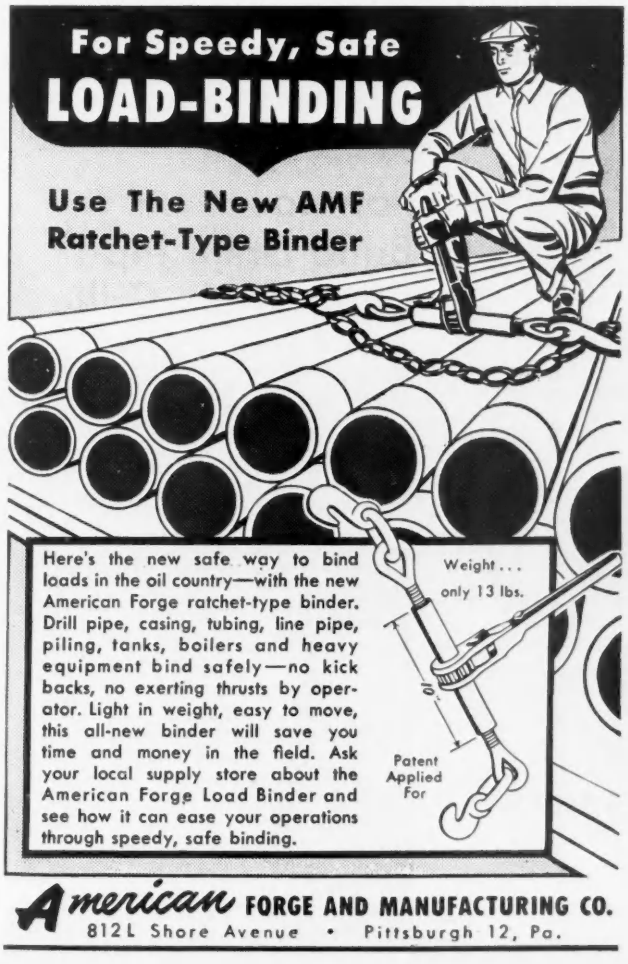
HOW TO—Remove Paraffin from Marine Pipe Lines

Paraffin in oil produced from submarine fields can cause trouble if the pipe line carrying a field's production to shore becomes clogged. To prevent excessive accumulations of paraffin in these underwater lines, a method can be devised as illustrated to run a pig occasionally to clean the line. This operation can be performed without closing in the field.

The hookup shown was designed primarily for running a pig through this six-inch crude line which carries about 2000 barrels per day to a tank battery about ten miles away. Wells flow into a tank battery platform in the field where the gas is removed and the oil is flowed through this line. Several wells flow into a manifold at about 150 pounds pressure, and the fluid is then directed into separators after which the oil is flowed through this pipe line.



Lubricator for the cleaning pig parallels the line on the floor of the platform as shown and is blocked off by two gate valves. End of the lubricator is closed with a blanked flange which can be removed to insert the pig. This is done while the flow of oil is through the top leg containing a plug valve. Once the pig is in place, the plug valve is closed, and both gate hand-wheel valves are opened, thereby placing the 150 pounds pressure behind the pig and forcing it into the line. Oil is discharged into a special tank on shore for further treatment to remove the paraffin sludge. In this manner, the line is kept clean and maximum flow is assured.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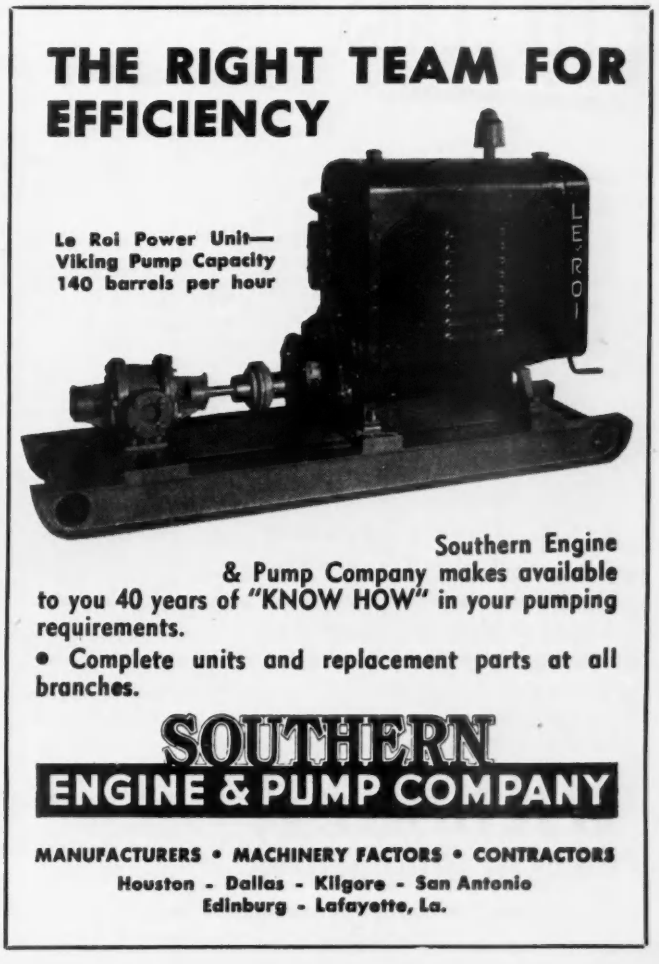
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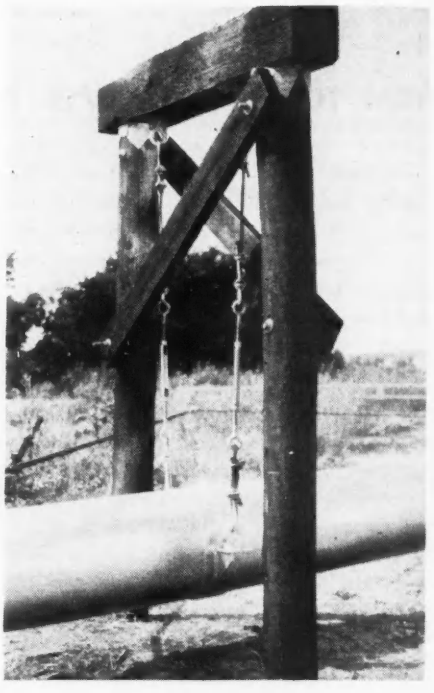
HOW TO—
Suspend Line for Overhead Approach

To absorb the changes in length of a 24-inch pipe line without imposing stress on the buried portions of the line, one company uses a long S-shaped tie-in at the shore ends of the bridge, with the pipe carried in saddles at intervals so spaced as to eliminate sags in the pipe.

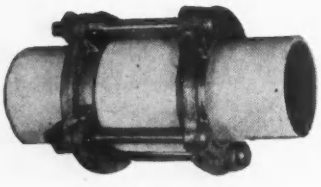
Each saddle is welded to the line to provide seal against possible corrosion at that point, and the saddle ends are equipped with eyes which are welded on with the flat side parallel to the pipe wall. By means of these eyes the pipe is suspended on twin cables from an overhead bent or frame. Turnbuckles in the supporting cables between frame and saddle enable the tension on both supporting cables to be equalized.

The frames are set into the ground along the line of the "S" which the pipe follows, with the axis of each set so as to bring it across the normal run of the pipe at that point.

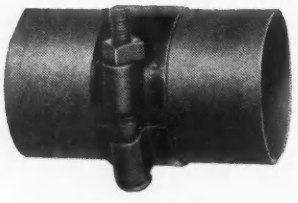


When so supported, the pipe can expand or contract on the bridge and the change thus brought about is absorbed through the length of the "S" bend without imposing concentrated stress at any point.

Creosoted timbers and galvanized fittings provide long life for the supports, with the saddles being painted in aluminum along with the pipe to which they are attached.



COLLAR CLAMP
Styles 4 and 41, for repairing and preventing leaks through threads of screw collars.



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Style 77B, for repairing small leaks and holes in the run of pipe.

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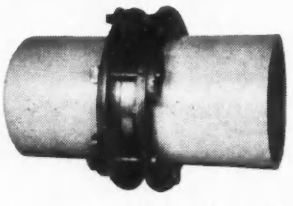
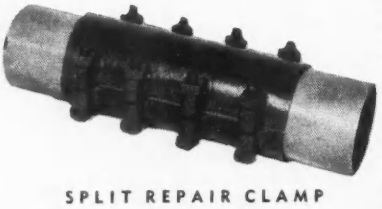


POROUS-WELD CLAMP
Style 55, for repairing circumferential weld leaks.



SPLIT REPAIR CLAMP
Style 79B, for repairing pitholes and longitudinal splits in pipe.

DRESSER REPAIR CLAMPS

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HOW TO—
Build Drain Pipe Catch Basin Grille

Where reclaimed line pipe is used for station yard drains, a catch basin for storm flow can easily be made with a cutting torch without removing the line or involving any concrete or masonry to trap the surface runoff.

At a point where ground water crosses

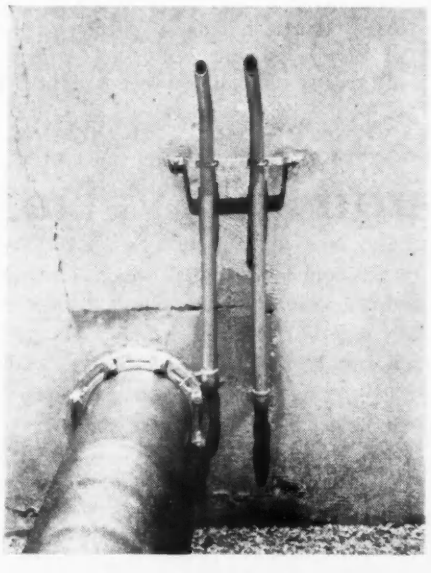
the line the pipe is bared, and a series of transverse slots are cut into the upper third of the pipe. These slots are spaced so as to afford a strip of pipe metal between openings strong enough to carry the weight of the power-driven mower, while the slots themselves are held to a width which will prevent trash, sticks or leaves from entering the pipe.

By sloping the turf down to the slotted pipe around the opening thus made, washing of the ground can be halted, and the approach for the mower is smoothed.

HOW TO—

Construct Vent for Engine Crankcase

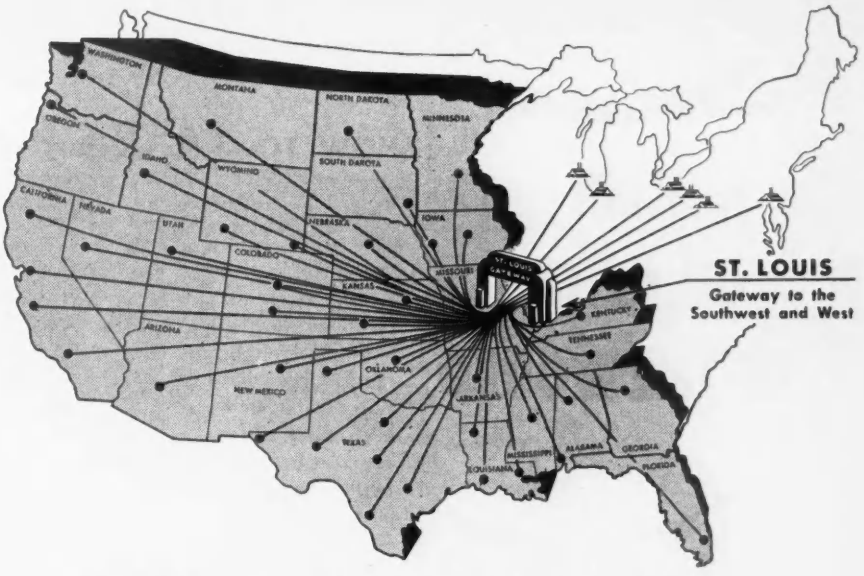
Rather than vent the crankcase to the interior of the station, one pipe line carries twin vent lines through the pipe trench to the outside of the building. There the lines are fitted with ells and



short risers, the latter terminating in ends bent outward through 30 degrees and the ends cut off in a vertical plane when set.

These vent lines, in addition to carrying any oil-contaminated vapors to the outside of the building, also serve to collect much of the oil which is carried by the vapor, allowing it to drain back into the engine sump, and there to be picked up again by the lubricating system.

To maintain the vent stubs in an upright position, they are clamped by U-bolts in a strap which hold them against a wooden block—this latter to allow the pipes to be held tightly to prevent possible vibration and noise.



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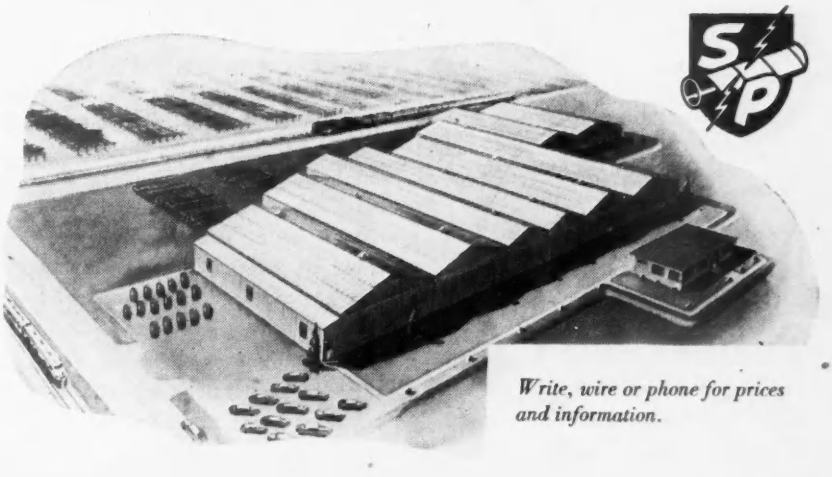

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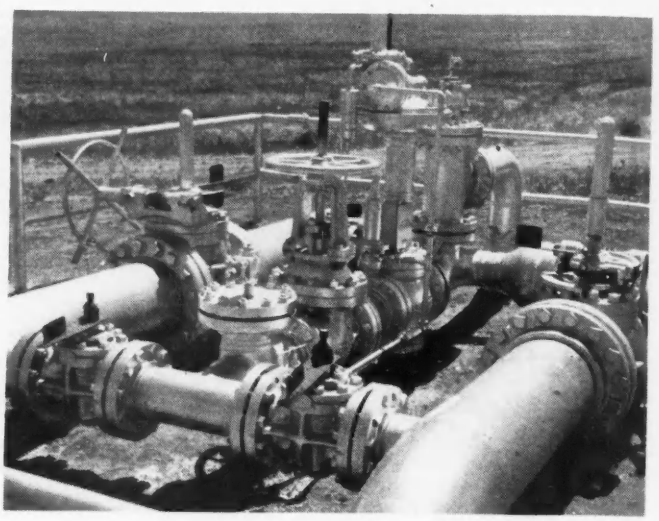
HOW TO—Make Flow Direction Flags



One company has adopted the practice of equipping each plug-type valve with a plainly visible, metal flag painted in bright red, in order that line riders and other workmen can tell at a glance whether a particular gate or valve is opened or closed. In the pressure regulating station illustrated, each of the five valves is equipped with a flag secured to the square of the plug stems. The flag is a narrow piece of sheet metal about 12 inches long to which is welded a vertical rectangular fin of similar gauge metal. Painted red and positioned atop the valve, the flag enables the workmen to determine the valve position without closely inspecting each of the units.

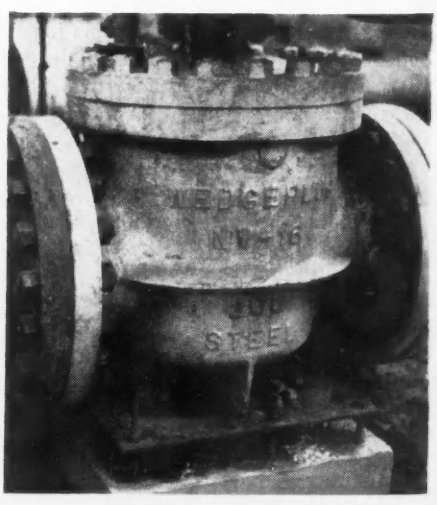
When a valve is painted and repainted numerous times with bright aluminum paint, the small pointer with which the valve is equipped becomes more difficult to see from a distance. Addition of the red flags is an inexpensive and convenient means of eliminating possibility of errors.

HOW TO—Support Large Plug Valves

A construction practice of a large pipe line system is a method of supporting large and heavy steel plug valves located at the booster station site. Flanging up such large valves in a line is not an easy job. Flange bolt holes in the pipe flange and the valve body flange must meet before the bolts can be inserted. The 16-inch valve weighs more than 1000 pounds and is not easily manipulated.

At the location where the heavy plug valve is placed in the line, a concrete foundation was poured so that its top surface was four or five inches below the bottom of the valve. Set in the concrete were several three-fourths inch bolts placed around the edge of the foundation. Matching holes were cut into a one-half inch steel plate to accept the bolts. Nuts were placed both on top and bottom of the steel plate so that its level could be altered by adjusting the relative position of the nuts screwed on the vertical bolts.

Steel fins cast into the valve body serve to support the valve in an upright position. Once the valve rested on the steel plate, its height could be adjusted, or it could be angled to one side as needed to match the flange bolt holes on the pipe line. An additional advantage is offered by this adjustable steel plate. Changes in length of the pipe due to temperature changes force the valve to move slightly. The steel plate acts as a bearing on which the supporting fins may slide.



Spain's OIL Possibilities

By Ing. P. H. SAMPELAYO
Spanish State Geologist,
Member, Council of Mines, Spain

SPAIN IS ONE of the few European regions which has had little systematic petroleum exploration. Generally, many of the geologic conditions are similar to those of France, Italy and French Morocco where oil has been found in lesser quantities, and it is believed that a number of the sedimentary areas warrant more serious investigation. Scattered showings have been found, but drilling has been sporadic.

ALTHOUGH oil showings have been mentioned in old reports dealing with Spanish geology, scientific investigation of oil possibilities in Spain actually were not begun until the turn of the century. Before that period the only reported shows included gas at Gaztiain, mud volcanos at Hornos, small quantities of light crude, sometimes with the appearance of having been distilled, as in wells in the Province of Cadiz or in springs in Huidobro; crude oil in small pits at Zamanzas, or in wells at Robredo-Ahedo; and asphalt occurrences at Maeztu.

Many of these indications were identified by Spanish scientists who had visited American oil fields. Even now very little oil reconnaissance has been done and too few wildcats have been based on scientific data to permit any definite theories to be formulated. Tests drilled have averaged only a well to each 15,000 square miles of area; and many were shallow and located without benefit of geology or other scientific methods. Only about a dozen wildcats have been located with such work, and several of them have reported showings of oil or gas. The discovery of oil during the past few years in countries having similar geologic conditions as those in Spain has aroused hope that commercial production might be found in Spain.

The first results from primary investigations, which included drilling shallow wells, may be summarized as follows:

1. Scattered showings of oil similar to that produced in the U. S., Mexico and Roumania.
2. Oil found in Mesozoic formations, mostly limestones, as a rule in marine facies and near Triassic outcrops.
3. Indications at some distances from the coastal regions and at elevations 1000 to 2500 feet above sea level.
4. No commercial production was developed and the oil found was generally very light and appeared to have been purified by its migration across shaly beds.

TABLE 1

LOCALITY (Province Shown in Parenthesis)	Geological Formation	Depth in Fee
1—Villamartin (Cadiz)	Triassic	2300 (plus)
2—Lebrija (Sevilla)	Tertiary	985 (plus)
3—C. de Trevino (Vizcaya)	Oligocene	2100
4—Ozana (Burgos)	Oligocene	656
5—Elorreo (Vizcaya)	Cenomanian	1970
6—Leva (Burgos)	Cenomanian	2165
7—Gaztiain (Navarra)	Senonian	5445 (plus)
8—Aras (Navarra)	Miocene	2300
9—Jaizquibel (Guipuzcoa)	Eocene	1640
10—Polanco (Santander)	Lower Cretaceous	2300 (plus)
11—(E) Bornos (Cadiz)	Tertiary and Triassic	1640
12—Tona (Barcelona)	Eocene	1640
13—(E) Robredo-Ahedo (Burgos)	Lower Cretaceous	3315 (plus)
14—(E) Ajo (Santander)	Lower Cretaceous	3936
15—(E) Fuentetoba (Soria)	Lower Cretaceous	1305 (plus)
16—(E) Ronda (Malaga)	Miocene	1640
17—Chinchilla (Albacete)	Tertiary	1970
18—Tremp (Catalonia)	Garumnian	5576
19—Oliana (Lerida)	Eocene	7639
20—Burgo de Osma (Soria)	Upper Cretaceous	Drilling
21—Zamanzas (Burgos)	Wealden	Drilling

Between 1920 and 1930, three wells were drilled past 3280 feet. After 1945 two American rotary rigs were imported into Spain capable of drilling to 8500 feet.

The deepest wildcat drilled in Spain is at Oliana (Lérida) and was abandoned after attaining 7639 feet. Currently two wildcats are being drilled at Zamanzas (Burgos) and Burgo de Osma (Soria).

In Table I, which lists wildcats drilled in Spain, it must be pointed out that many of the earlier wells were located with little scientific background.

Geophysical reconnaissance work has been done in Spain but it was undertaken in the early days of the science and before it had progressed to its present status, as follows:

1. Determination of the faults in the Leva anticline (Burgos).
2. Geological structures defined at Berlanga and Budgo de Osma (Soria).
3. Anticline defined at Basconcillos del Tozo (Burgos).
4. Reconnaissance of the Garrucha zone (Almeria).
5. Triassic dome of Cofrentes (Valencia) defined.

Petroleum Geology

Of the approximately 193,050 square miles of surface area in Spain, only about 38,600 square miles, or roughly one-fifth may be considered interesting from the standpoint of petroleum possibilities. The remainder of the area is pretty well ruled out by certain tectonic and other conditions. According to current geologic knowledge of the country, the following conditions must be ruled out:

1. Eruptive and metamorphic formations.
2. Paleozoic formations, which are mostly severely folded and faulted by metamorphic action. As yet no oil indications have been found in the Paleozoic, but oil could exist in hidden folds covered by Mesozoic or Tertiary formations.
3. The continental Tertiary sediments.

In some places oil could be found in underlying Mesozoic sediments, but probably at great depths.

On the strength of geological reconnaissance and wildcats drilled, it seems that the zones offering best prospects for developing commercial production are in the north (south of the Pyrenees and Cantabrian mountains), and the Province of Cadiz in the southwest.

Several tectonic phases have occurred, ranging from the Paleozoic to as recently as the Miocene. These have not only caused the formation of the Pyrenees and Iberian mountain ranges, but have also affected minor ranges such as the Celtiberian, which unites the Cretaceous folds of Soria, Burgo and Logroño with the Cantabrian massif of Zamanzas and Sedano, and continues up to the great Cretaceous geosyncline of the Basque provinces.

In the northern zone the top of the mountain ranges are generally synclines and the oil shows are found on the mountain plains. These shows are sparse with no continuity, and no encouraging results have been obtained through wildcats drilled in this region, with the exception of those at Zamanzas and Robredo-Ahedo.

The Alpine tectonic phase in Oligocene times has violently affected the geological formations, resulting in overthrusts and diapiric phenomena which can seal oil deposits, principally along faults due to the presence of shales and clays, frequently of Keuper age. Much detailed geological reconnaissance work is necessary in order to evaluate the oil accumulation possibilities resulting from such phenomena.

Geologists working in Spain should familiarize themselves with the types of Spanish tectonics, which vary from extensive overthrusts to more or less violent anticlinal folds or zones of intense diapirism. The geologist must also consider the lateral variations in the thickness of the geological formations which in Spain change very rapidly.

Thus, the Upper Cretaceous, which in many places is only 1000 feet or so in thickness, is nearly 10,000 feet thick in some parts of the Basque Geosyncline.

The Wealden in continental facies which in the Spanish Meseta fades out completely has sediments more than 6500 feet thick in the Soria-Logroño region.

Another example is the marine Eocene which, quite thin in some regions, is more than 6500 feet thick in the Southern Pyrenees.

The Spanish regions having petroliferous possibilities can be separated roughly into the two following groups:

Anticlinal Structures

1. Burgos—Santander
2. Soria—Cuenca—Guadalajara
3. Basque Provinces

Diapiric Tectonics

4. Cataluña Pyrenees
5. Aragon and Eastern Spain
6. Andalucia

Local Data

Basque Provinces (Santander-Burgos): In Northern Spain there are long anticlines that extend from Santander and Burgos, to Navarra and the foot of the Pyrenees. These anticlines are formed by Upper and Lower Cretaceous sediments, generally with a Liassic or Jurassic core and a Triassic basement, which outcrops at many places.

Oil shows are fairly abundant, especially in the Wealden sands and sandstones, and in the writer's opinion, many of the outcrops which are not well interpreted are Cretaceous sandstones sealed by clays of the Keuper.

Gas seeps from Cretaceous, sandstones and shales have been found in a zone symmetrical and parallel to the zone in France, north of the Pyrenees, where commercial gas in some abundance is being produced, thus leading to the belief that similar gas deposits may be found in the Spanish Pyrenees.

There are good closed anticlines in the Cretaceous of the Basque provinces, such as the Senonian-Turonian dome of Gaztiain (Navarra), where a test drilled to 5445 feet, produced gas flares several feet high. The well was abandoned because of inadequate equipment.

The writer is of the opinion that the Triassic tends to seal the Mesozoic porous beds diapirically so that it is necessary to make a careful examination of the Cretaceous stratigraphy up to the Cretaceous-Triassic contacts when locating tests.

In the Province of Burgos, especially in the zone of Sedano, Gallejones and Soncillo where the best oil shows of the region are to be found, the Cretaceous anticlines are about 12 miles long and trend southeast-northwest.

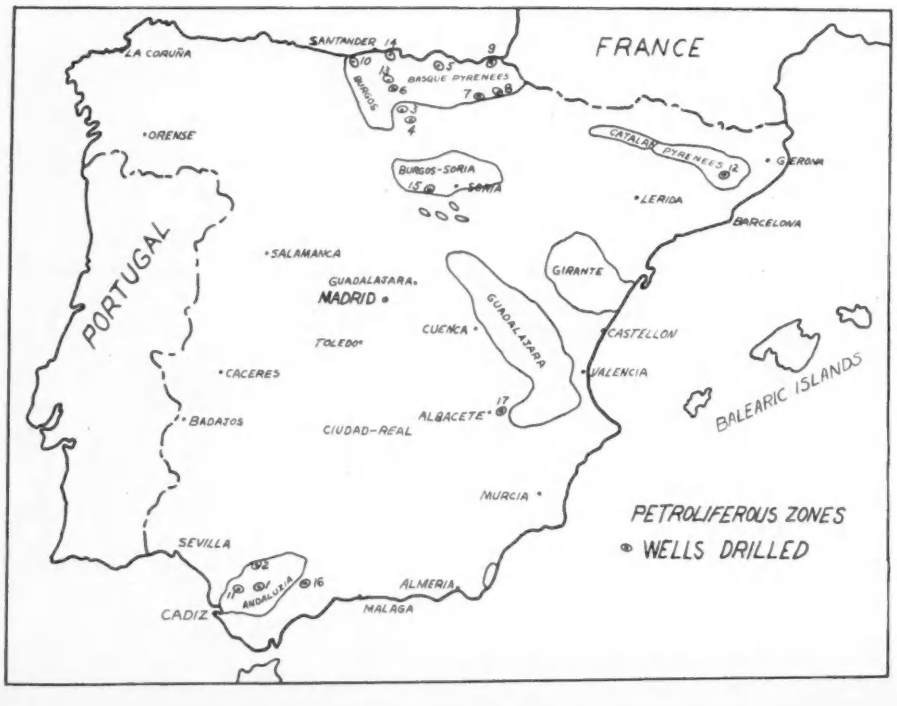
The anticlines of Villasana, Soncillo, Zamanzas, Basconcillos del Tozo and Ubierna are normal to the trend, showing the complexity of the tectonics.

The Cretaceous zone outcropping at Santander is divided in two sections, one covering a great part of the Province of Burgos and the other spreading toward the Cantabrian mountains and then following the southern flank of the Pyrenees.

The Arreba Anticline, Province of Burgos, is west of the Leva Anticline and can be traced for many miles in the big erosional valley of Zamanzas, formed by Lower Cretaceous beds and crowned on its borders by Upper Cretaceous limestone beds. The slopes of the valley, 1000 feet deep, are formed by the Cenomanian, Turonian and Senonian fossiliferous limestones. The bottom of the valley is Wealden with sands, sandstones and clays.

Several stratigraphic tests drilled in the Wealden have penetrated the Liassic at about 1300 feet. Oil shows have been found in these wells, both in the Wealden and the Liassic, the oil in this latter formation being much lighter. As a result of the shows a rotary rig was moved in and drilling started last July with the well now reported below 2000 feet.

The greatest thickness of the Cretaceous folds occurs from the Hoces de Reinosa (Santander), where the Permian and Triassic outcrop up to the Wealden of Urbión and Gameros (Province of



Soria), although the greatest thickness of detrital Aptian should be near the axis of the geosyncline near Ceanuro and Lirna (Vizcaya).

Undoubtedly, the best shows obtained in this region of Northern Spain were in the stratigraphic tests at Zamanzas, where about 75 barrels of oil was bailed out, and in the Robredo-Ahedo well (Burgos) where about the same quantity of oil was bailed.

Lower Pyrenees (Catalonia): In Catalonia, as in the whole of Northern Spain, oil indications are found in the Mesozoic and the Eocene, which were folded during the Alpine tectonic phase which took place in Oligocene time. The folds are interrupted to the east by the old massif of Ampurdán, but toward the west, up to the Cretaceous structures of the Basque provinces, there are a series of anticlinal structures, often domelike, but frequently open to the east, where the Mesozoic thins out toward the Mediterranean.

Other oil shows have been found in the foothills region of the Pyrenees along a band that crosses the Provinces of Gerona, Barcelona and Lérida.

The deepest wildcat drilled in Spain was completed in 1948 in this region near the village of Oliana (Lérida) and attained a total depth of 7639 feet. The well was on a high-rimmed, perfectly elongated dome and spudded in Lutetian (Eocene) shales which were never penetrated, probably due to a lateral compression caused by severe tectonics which greatly augmented the thickness of the shales. The well was dry and no porous zones were encountered. The well was drilled by a Spanish company, owned in partnership by Socony-Vacuum Oil Company and the Spanish "Compañía Española de Petróleos."

Among the many oil shows in Catalonia may be mentioned:

1. Boixols—Light oil in Cretaceous limestone cavities.

2. Ruitart—Laminated shales with oil flowing drop by drop in a horizontal shaft 2300 feet long.

3. Montagut-Oix (Castellfullit, Gerona)—Compact Eocene gray shales containing drops of oil.

4. San Lorenzo de la Muga (Gerona)—Shales with oil in their joint planes and cavities.

Province of Soria: The lines of folding in this region have a northwest trend and two separate zones can be considered in this region. The western zone has only Lower Cretaceous structures which extend to the great tectonic "window" of the Sierra de la Demanda, (Paleozoic); the southern zone has Upper Cretaceous structures, covered mostly by Tertiary strata, nearly horizontal.

This Upper Cretaceous anticline cuts through a table land which rises to 2950 feet above sea level, is symmetrical and apparently is not faulted. Two geological cross-sections, with a north-south strike across the Duero valley, would cut the Andaluz and Berlanga anticlines in the east, and the Ucero, Burgos de Osma and Gormaz structures in the west. About ten anticlines are found in this region.

The same company which drilled the Oliana (Lérida) wildcat is exploring the Burgo de Osma anticline with a test last reported drilling below 3300 feet. Wells drilled on this anticline will probably cut Upper and Lower Cretaceous, Liassic and Triassic, with oil possibilities in the Lower Cretaceous, Lower Liassic and Upper Triassic.

The most important oil shows in the Province of Soria are found along the flanks of the Pico Frentes ridge. Here, the Albian sands and sandstones which outcrop below the Cenomanian shales and limestones are impregnated with heavy black oil. The oil sands lens out so that the continuity of the horizon which is of continental or lacustrine facies, is somewhat doubtful. These tar sands have been worked in underground mining for asphalt since 1850. A wildcat drilled by the Spanish government in 1928-29, reached a depth below 1300 feet, and cut 10 or 12 horizons of asphaltic sands. A similar outcrop of tar sands is to be found in Torrelapaja, east of the city of Soria, where asphalt also was mined some years ago.

Andalucia: The oil shows of the Province of Cadiz in Southern Andalucia have been known for many years. Most of the shows occur in very shallow wells or small springs and consist of a very light amber-colored oil.

The low lands of Cadiz are covered by Tertiary deposits, Eocene, Oligocene, Miocene and Pliocene, but the Triassic basement extrudes with a diapirical tendency, through the more recent sediments. Undoubtedly, there is a relation between the appearance of the highly laminated Keuper shales and clays and the oil shows. Some of the oil impregnation in the Triassic folds passes to the cavities of gray limestone beds which may be considered Upper Triassic or, perhaps, Lower Liassic.

There is a striking similarity between the oil occurrences in Andalucia and those of Northern Morocco and in the Province of Emilia in Italy.

The best oil indications in Cadiz are those of Villamartin de Bornos, where in a small pit 460 feet deep light yellowish crude can be bailed out in small quantities. Similar oil shows are known near the villages of Conil and Chiclana. At Chiclana a structural test was drilled by an agency of the Spanish government on a small diapiric Triassic outcrop. Two wildcats drilled near Bornos and carried to 892 and 1640 feet, respectively, were dry.

The writer believes that a more detailed geological reconnaissance should be made of the petroliferous zones of Cadiz and structural or strat tests be drilled to determine if there are oil deposits in the porous Tertiary beds that could be sealed by the Triassic diapiric plugs.

In the above article certain geological terms and expressions are mentioned which are not normally used in the U. S. For those not familiar with some of the European terms the following may be in order:

DIAPIRISM: *A term first used by the Roumanian geologist Mrazec and now commonly used in Europe, denoting that older strata have been pushed up through newer formations, the contacts of the formations being sheared and sealed off.*

DIAPIRS: *Similar to Texas Gulf Coast salt domes. For example, the impervious Triassic shales in a Triassic "diapir" would seal off porous beds in contact with newer formations.*

KEUPER: *The superior stage of the Triassic of German facies.*

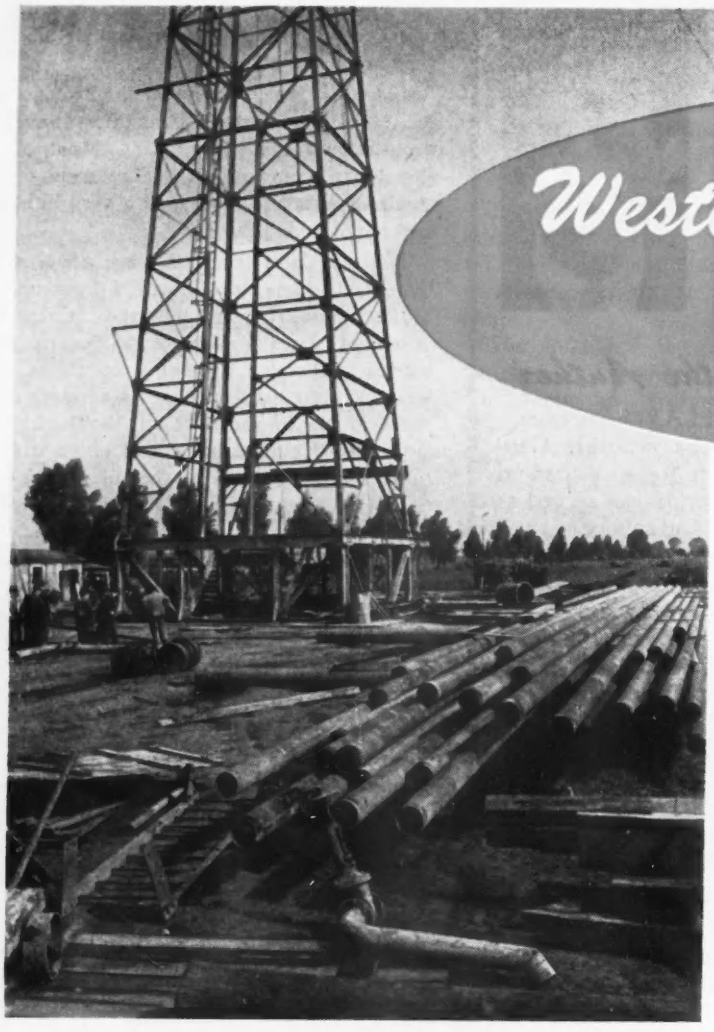
SENONIAN AND TURONIAN: *Two stages of the Upper Cretaceous.*

LIASSIC: *Period belonging to the Lower Jurassic and normally lying on the Triassic.*

About the Author

P. H. SAMPELAYO has been a member of the Spanish Geological Institute for 40 years and during that period has served as state geologist and supervised and observed several wildcat tests drilled in the Peninsula. He is the author of many books and articles and has specialized in a study of the Spanish Paleozoic. His article constitutes perhaps the first comprehensive review of the oil possibilities in Spain to be published in this country. He is a member of the Spanish Academy of Sciences and is a director of the Spanish Council of Mines.

Western Germany's Output Up



Rigging up for a wildcat in the Hanover district.

PRELIMINARY reports from German oil fields, including a record production for the month of December, indicate that nearly 6 million barrels of oil were produced in Western Germany during 1949, an increase of about 32.4 percent over the substantial output for 1948, and a quantity sufficient to meet approximately one-third of the country's domestic requirements. The 1949 production was 52.5 percent more than Germany's output of crude petroleum for 1938, the last full year before the beginning of World War II.

As a result of successful exploration during the past year, and further expansion and definition of fields discovered during the past three or four years, some German experts have forecast that, despite the natural decline of older fields, Germany's total output should approach 15 million barrels yearly within a comparatively short time. Attainment of such a goal is dependent on a number of factors, including availability of drilling and production equipment as well as freedom of action.

The greater part of the increase registered for 1949 was due to the fields in the region between the Ems River and the Dutch border. Surprisingly, Nienhagen-Haenigsen, one of the older fields of the Hanover district, with its production of 885,000 barrels, was able to actually show an increase over 1948, and help account for a net gain of nearly 300,000 barrels for the district.

Top Developments

Most outstanding development of the year took place in the Emsland; and the Georgsdorf field showed the greatest gain. This field was discovered in 1944, but saw little development until 1947 and 1948. Production totaled 371,672 barrels in 1948. During 1949 an increase in development made it possible for the field to produce a record total of 934,000 barrels and lead all other German oil fields in total output. In Emlichheim, along the Dutch border, production was increased by 99 percent during the past year to bring total output for the year to 913,000 barrels and second place among the country's oil fields.

As a whole, the Hanover fields maintained yields better than had been expected. In the Steimbke field, near Nienburg, output was increased by about 44 percent and had risen to about 42,500 barrels in December with prospects for further increases during the coming year. Yields have also risen at Wesendorf, Hademsdorf, Broistedt, Oberg Calberlah and Gifhorn. On the other hand, additional drilling has failed to halt the declines at Eicklingen and Etzel. The Neinhagen-Haenigsen fields were able to show increases through the successful development in the Kuhlenberg and Haenigsen areas.

In Hamburg new producing areas were found in the Heide fields. Continuation of secondary recovery methods is believed responsible for an over-all increase of 7½ percent in production from the Schleswig-Holstein and Hamburg districts. No new production was found to bolster the Baden area in the Rhine Valley, and production decreased slightly.

As a result of a sharply accelerated drilling program which included wild-

catting as well as development drilling, seven new oil fields were discovered in 1949, none of which were fully defined, but several of them giving promise of developing important production. In the Emsland there is hope for Ruehlertwist-Ruehlermoor and Scheerhorn. In Hanover the Suderbruch and Eldingen fields were brought in as well as the extension at Neinhagen-Haenigsen known as Kuhlenberg. A new producing area was found at Elpersbuettel in the Schleswig-Holstein district.

The exploratory campaign included some deep drilling in the older areas, and recently a well at Steimbke was carried to 12,600 feet to become the second deepest well yet drilled in Europe. This test, drilled by Gewerkschaft Brigitta, a joint subsidiary of Shell Group and Standard Oil Company (N. J.), was meant as a test of the possibilities of the subsalinar Zechstein in the Hanover district, and penetrated a salt series more than 6000 feet in thickness. There are still no details as to findings in this deep test.

The Lingen-Dalum field, in the easterly part of the Emsland area, recently was given additional importance through a one-mile north extension, with the well apparently a small producer when first brought in. At first it produced at a rate of from 20 to 35 barrels daily, but upon treatment with acid the flow was increased to a steady 110 to 125 barrels daily under production conditions.

The importance of this well is twofold, since it not only brings a considerable amount of additional acreage into the proved category, being 6000 feet northeast of previous production, but it also is the first production of commercial importance in the Emsland from the Apt formation, which had previously been tested several times in the area without encouragement. Structurally, the extension is in a fault block adjoining, and slightly lower than, the original fault block believed responsible for the accumulation in Lingen-Dalum.

The Ruehlertwist area, mentioned above as a recent discovery, has now been extended another mile in a westerly direction by Ruehlertwist 4, which is a commercial flowing well from sand at 2640-755 feet. From present indications, this new field will probably cross the Dutch border, since this new well brings production within a mile, and it is reported that a well on the Dutch side has found oil.

The new production at Kuhlenberg in the Nienhagen area is not strictly a new field, but a new producing sector opened by a well which drilled to 3940 feet, finding production in the Wealden on the western flank of the salt dome. Not a large producer, nevertheless the first and subsequent wells have flowed at rates up to 150 barrels daily since discovery in September.

At the latest report there were about 162 drilling rigs operating in Western Germany, of which 34 were portable outfits used for core-drilling to 350 feet or less. The remainder ranged from a comparatively few light rigs for shallow development drilling to a larger number of heavier rigs capable of reaching all present production levels.

There is now little doubt that total footage drilled for oil and gas during 1949 will be in excess of 985,000 feet, and may even reach 1 million. This figure was mentioned as a goal for the German drilling industry early in the year, with the knowledge at that time that it would amount to nearly double the footage drilled in 1948, a very active year. The addition of new exploratory equipment during the past year will assist in maintaining the volume of drilling devoted to exploration. During 1949 it is estimated that about one-half the total footage was drilled in exploratory wells. Another factor in making more hole during the year has been the lifting of certain restrictions to allow the import of American rock bits.

Changing Picture

The over-all picture of the petroleum industry in Germany is showing a definite change, with increased industrialization accounting for steady increases in consumption. At the same time, while total volume of imports were rising through the third quarter of 1949, the comparative volumes of crude oil and products changed materially, with systematic enlargement of refining capacity.

During the first half of 1949 total imports increased by nearly a third over the amount imported into the Bi-zone during the first half of 1948. However, the amount of crude involved increased four-fold over the comparable period in 1948.

According to plans early in the year it had been thought that by making use of refining capacity in the Wesseling and Gelsenberg hydrogenation plants, it would be possible to halt completely the import of anything other than crude, with consequent savings to the German economy. Meantime, the decision was reached to dismantle the Gelsenberg plant and this work was started early in the second half of the year. It was then expected that it would not be earlier than late 1952 or early 1953, upon completion of anticipated new cracking facilities, that imports of products could be discontinued. Late in the year the picture changed again as decision was reached to allow the plant to operate.

During the third quarter of the year, total volume of imports rose to 4½ million barrels, or about 18 percent more than were brought in during the second quarter, and the proportion of crude to products remained at about half-and-half. The largest single item included in products imported is diesel oil, which makes up about two-thirds of the total product imports.

At the same time there are still some quantities of products being exported from Germany. These are, for the most part, confined to bunker fueling of foreign ships calling at ports in Northwestern Germany, and some exports of bitumens and petroleum coke, most of the latter two going to Switzerland.

Pumping wells in the old Wietze field, producing since 1874.

Structural Features of the *Canadian Shield*

By J. M. HARRISON
Geological Survey of Canada

THE CANADIAN SHIELD'S Precambrian bedrock covers about half of the area of Canada, and its characteristics have a distinct bearing on petroleum geology in sedimentary areas. It is fortunate from a geologic viewpoint that there are large areas where the bedrock has been swept clean of all glacial drift and other surface debris to present an unrivalled opportunity for study of structural characteristics of the bedrock itself. Even where obscured, it is found that characteristics of present topography are controlled to a large degree by the underlying bedrock. Studies to date have given much encouragement along the lines of applying results of bedrock studies from air photographs to the effect on the accumulation of oil. This article is published by permission of the Director, Mines, Forests and Scientific Services Branch, Department of Mines & Resources, Ottawa, Canada.

PETROLEUM geologists are exploring more and more the basement rocks on which oil-bearing strata rest. This is partly, no doubt, in the interests of pure geology, and also to aid in learning the reasons for the presence of favorable structures.

In areas of interest to geologists the basement rocks are covered by younger strata, and little can be known of their structures, or of the effect these structures may have, except by data from drilling and seismic records, and by the study of air photographs. However, the Canadian Shield of Precambrian rocks presents an unequalled series of exposures for the study of the "basement complex," and it is to be hoped that a knowledge of bedrock features in the Shield will assist petroleum geologists to interpret structures occurring below some of the known oil fields.

Air photographs of Shield areas provide excellent illustrations of structures to be expected in basement rocks. Many such pictures are included in the catalogue of outstanding air photographs that has been assembled at the Geological Survey of Canada by Lang, Bostock, and Fortier (1947), and from which the illustrations given here were assembled.

Physiography of the Canadian Shield

The Canadian Shield is the bedrock of more than 2 million square miles, or about half of all Canada (Figure 1). It is a dissected peneplain, and, although the topography is rugged in detail, the skyline in any one locality appears monotonously level. Local relief is usually less than 300 feet, but in the higher parts, along the eastern and northeastern margins of the Shield, the relief may be 3000 feet or more. In general, however, elevations above sea level are 2000 feet or less.

As a result of Pleistocene glaciation the original topography has been somewhat modified. The drainage pattern was disrupted and a multitude of lakes was created that spill at random over the lowest points of their rims. Large areas are covered by various kinds of glacial drift that cover the bedrock completely and make it necessary to interpret the underlying rock structure by means of air photographs. In other places, however, the bedrock was swept clean of nearly all debris and was left better exposed for study than ever before. Of such, the most outstanding is that near Yellowknife, on Great Slave Lake, in the northwest part of the Shield (Jolliffe, 1945). Even in areas where the glacial drift obscures the bedrock it has been found that the features of the underlying rock control to a large degree the present topography of the Shield, and air photographs were quickly recognized as serving a vital purpose in the study of these features. At least as early as 1925 officers of the Geological Survey of Canada were using air photographs to assist field mapping and study of Precambrian rocks.

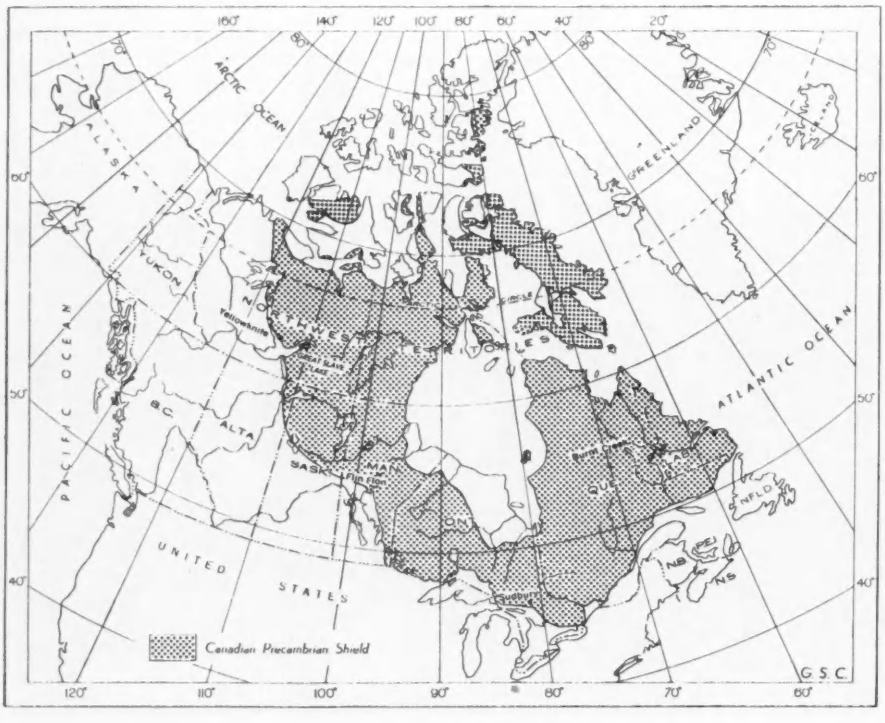


FIGURE 1. Canadian Precambrian Shield (shaded).

Precambrian Structures

Structures in the Precambrian rocks are not fundamentally different from

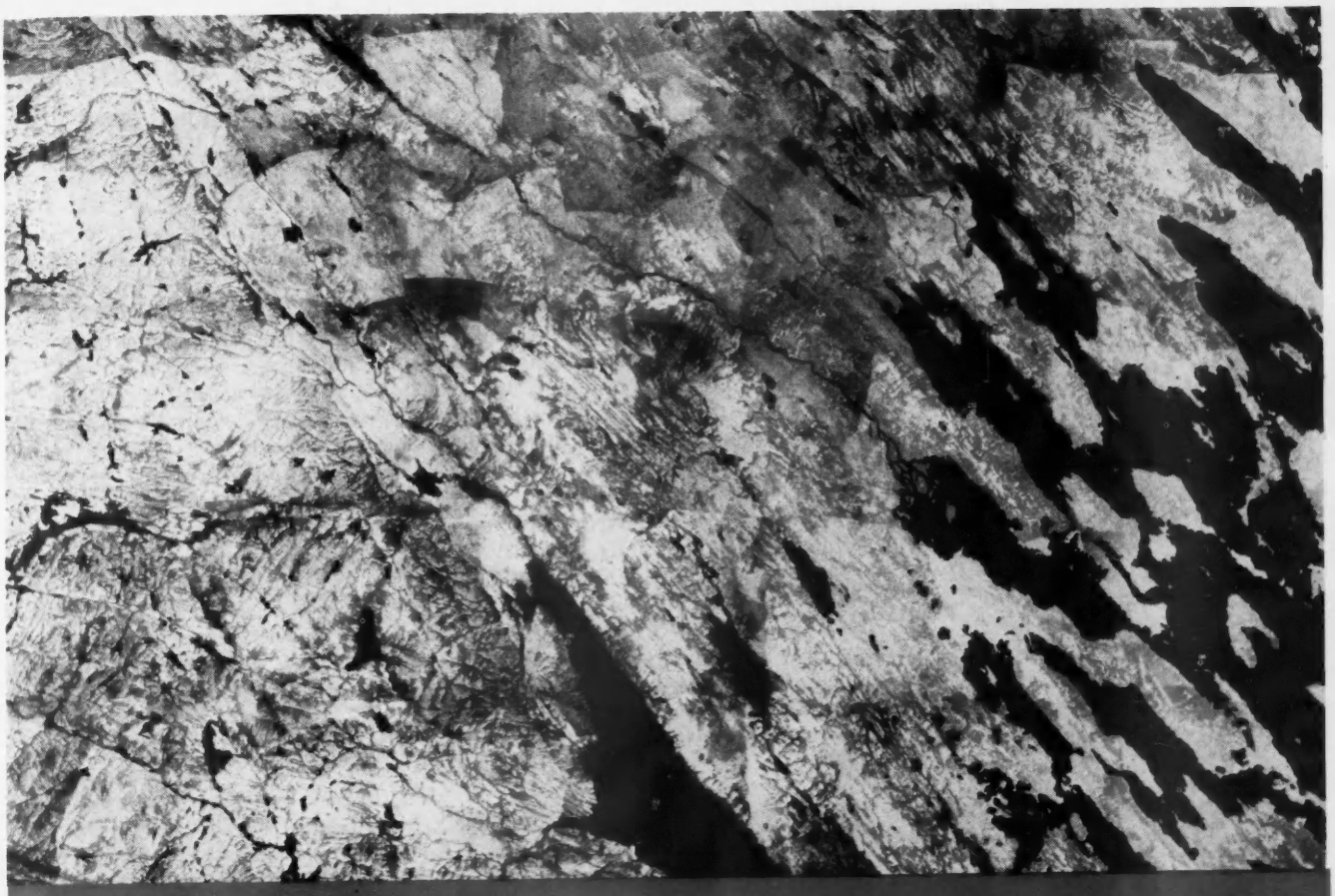


FIGURE 2 (above). Mosaic of Royal Canadian Air Force photographs compiled by the Topographical Survey. Area covered is immediately south of Burnt Creek, and shows the unconformable contact between Early Precambrian rocks in the west and Late Precambrian, iron-bearing, strata to the east. Mosaic No. RE4527.

FIGURE 3 (below). Faulted and folded Late Precambrian strata on Belcher Islands. RCAF photo A3915-14.

those found in rocks of other eras, but there is one fundamental difference in mapping an area in the Precambrian. In rocks of other eras, fossils provide a solid foundation for the stratigraphic column, a reasonably exact means of correlating from place to place, and a key to determine structure. In the Precambrian, on the other hand, a complete lack of diagnostic fossils means that the geologist must determine the structural picture BEFORE the stratigraphic sequence can be established. When it is also considered that structure is the main identificable control in the localization of mineral deposits it is apparent that the Precambrian geologists are at least as concerned with geological structures as those in the oil industry.

The rocks of the Shield lend themselves to study on air photographs because of a number of features inherent in them. Most of them have been folded so that the dips of beds are at least moderately steep and a great thickness of strata can thus be observed over a relatively short distance. Some distinct stratigraphic horizons can be traced long distances on air photos, and the broad lithologic divisions can be separated. Foliation in the rocks is commonly distinct and the general trend of folded structures can be outlined. Faults in many regions are more readily discernible than folds, although not all linear structures are due to faults.

Finally, the low relief and generally scant cover provide an uninterrupted view over large areas. It has been the writer's experience that sedimentary strata commonly show folded structures to better advantage, whereas areas of volcanic rocks exemplify faulting. In the Yellowknife area of the western Northwest Territories, intricately folded sedimentary strata and contrasted with complexly faulted basic volcanic rocks, and good illustrations of this contrast have been published by Jolliffe (1942, 1945). The most outstanding illustration of a fault in the Canadian Shield is probably the McDonald Lake fault of this area (Jolliffe, 1942), which has been traced for more than 300 miles. Such a structure, of course, cuts through all types of rocks. Had this fault been covered by Paleozoic sediments it would almost certainly have affected them for the irregularities of the fault line and differences in elevation on each side of the fault would have resulted in differences in initial dip, and thickness and compaction of the sediments. Further, a fault of such magnitude, and which displaces late Precambrian rocks, must have been subject to adjustments in Paleozoic time and could have at least warped, if not actually displaced, the younger formations. A mosaic of photographs, possibly illustrating such a feature, was shown to the writer at the offices of the Florida State Geological Survey. Faint lineaments could be discerned on the mosaic and they appeared to have a distinct relation to possible oil production in the Tertiary rocks. However, in field mapping, no evidence had been obtained for Tertiary faults, and the lineaments were regarded as being the results of buried Cretaceous faults, an interpretation with which the writer is in accord.

FIGURE 4. Compound fold (foreground) in Early Precambrian rocks on Baffin Island. Frobisher Bay in background. Note how the snow accentuates the structures. RCAF photo T212 R-18.

Quartz Veins

Some of the faults in the western Northwest Territories have been filled with a stockwork of vein quartz, and produce marked topographic ridges. These are known as "giant quartz veins," and one of them is illustrated by Lang (1948, Figure 3). The effect such a feature would have on younger strata is obvious. Many other examples of faulting in this area have been described and illustrated by Jolliffe (1942, 1945), Campbell (1948), Lang (1948), and Wilson (1948), and space will not be utilized here to reproduce them again.

In the more central part of the Canadian Shield, straddling the boundary between Manitoba and Saskatchewan, (Figure 1) several hundred square miles of country are underlain by intricately folded and faulted gneisses and schists that represent, for the most part, original sedimentary strata. In spite of the fact that 75 to 80 percent of the bedrock is covered by glacial debris, the structures over most of the area are clearly discernible on air photographs and can readily be plotted from them, as was done by Stockwell and Harrison (1948, Figures 2, 3, 4). In this region faults are not nearly so prominent, for most of them are strike faults of comparatively small displacement. Much of this region was once covered by a thin mantle of Paleozoic strata and, in one place, an outlier of Ordovician or Silurian dolomite has been preserved as a down faulted block within the Precambrian gneisses (Harrison, 1948), a striking example of definite post-Ordovician faulting, along a shear that dated from Precambrian time, and in an area that has been considered stable since Early Precambrian time. How much more likely

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that pre-existing Precambrian structures have been the loci of movement that have affected accummulations of sediments that are thick enough to have oil-bearing strata.

In the Great Lakes region of Canada, the area which is most productive of metals, glacial deposits are so thick and widespread, and forest cover so heavy, that little detail can be observed on most photographs. In this area are included the gold-bearing mining camps of Kirkland Lake, Timmins, Malartic, the copper camp of Noranda, and the Sudbury nickel basin. In most of this area photographs serve their best purposes, for the field geologist, in locating outcrops with a minimum of wasted effort, although Wilson (1948) recently has been endeavoring to interpret the broader structural features from them.

That part of Canada east of Hudson Bay is comparatively little known. It has, however, come into recent prominence with the discovery of large quantities of iron ore near Burnt Creek, at the interprovincial boundary between northern Quebec and the Labrador area of Newfoundland (Figure 1).

The deposits are in a belt of Late Precambrian strata that extends from the west side of Ungava Bay, on the north, for at least 350 miles southeasterly. Although these rocks are quite fresh in appearance they have, nevertheless, been intricately folded and faulted in many places. Only a small part of this belt has so far been photographed, but some of the pictures are striking illustrations of geological phenomena.

What is, apparently, a folded fold that lies about 25 miles north of Burnt Creek was illustrated by Harrison (1949). One of the most clear-cut features to be seen on vertical photographs of this region is the unconformable contact between older Precambrian rocks on the west and the younger strata on the east. It is shown in Figure 2, a mosaic made by the Topographical Survey of Canada from photographs of this region. Presumably the eastern contact of this belt once showed a similar relationship, but in those parts of it familiar to the writer the contact there is a fault or is covered by a mantle of glacial drift. However, these rocks were presumably deposited in a trough, and it is apparent that nearly all structures within it are parallel with the contact (Figure 2). Most of the faults in this belt are believed to be thrust faults (Retty, 1948), which dip northeast, and some of the folded structures are overturned so that the axial planes also dip northeast.

The Belcher Islands of eastern Hudson Bay are also formed of Late Precambrian rocks that contain large amounts of iron formation. Although little is known of their detailed geology, the old oblique photographs of them are excellent hunting grounds for outtanding illustrations of geological structure. One of many is shown in Figure 3. Faults can be seen cutting across folded strata and, as appears to be the case near Burnt Creek, some of the folding may have resulted from dragging along fault plates.

Farther north in Baffin Island, recent trimetrogon photographs are a delight to the structural geologist. Domes, basins, open folds, faults, tension joints, bedding, and all forms of structure can be seen in the contorted formations. Most of the photographs currently available were taken while some snow remained on the ground (July, 1948). Figure 4, showing a plunging, contorted anticline, illustrates with what clarity the drifted snow brings out details of structure. Another structure, pictured under such conditions in Baffin Island, was shown by Harrison (1949, Figure 2). It has been the experience of those who study structures in Shield areas that an aerial reconnaissance after the first light fall of drifted snow in the winter, or after most of the snow has melted in the spring, will frequently show clearly the faint structures that are difficult to distinguish but which may be decidedly important.

About the Author

DR. J. M. HARRISON was born in Regina, Saskatchewan, and won a B.Sc. degree from the University of Manitoba in 1935 and a Ph.D. from Queen's University, Kingston, Ontario, in 1943. On graduation from Queen's he was appointed to the staff of the Geological Survey and in 1947 was placed in general charge of field parties in northern Manitoba and adjacent parts of Saskatchewan. In early 1949 he was given charge of the study and field mapping program of the Geological Survey in the Labrador-Ungava iron range region of Northeastern Canada. For the academic year 1949-50, in addition to regular duties with the Survey at Ottawa, he is giving the lectures at Queen's University that were formerly given by the late Dr. E. L. Bruce.

Conclusions

Bedrock features in the Canadian Precambrian Shield are fundamentally the same as those to be found in other rocks that form "basement complexes." A study of air photographs and the related geological maps of Precambrian areas offers an unrivalled method of becoming acquainted with "basement-type" structures for those geologists in the petroleum industry who are concerned with the effect of such structures in rocks underlying potential or proven oil-bearing strata. From the magnitude of some of the faults, their distinctness as topographic features in the more or less flat Shield, and the fact that some, at least, have been active since Precambrian time, it can be inferred that such structures could have a considerable bearing on overlying petroliferous strata. Such results may be recognized at particular localities even now, and it is to be hoped that advancing knowledge and techniques will further aid in interpreting structures in the "basement complex," and their effect on the accumulation of oil.

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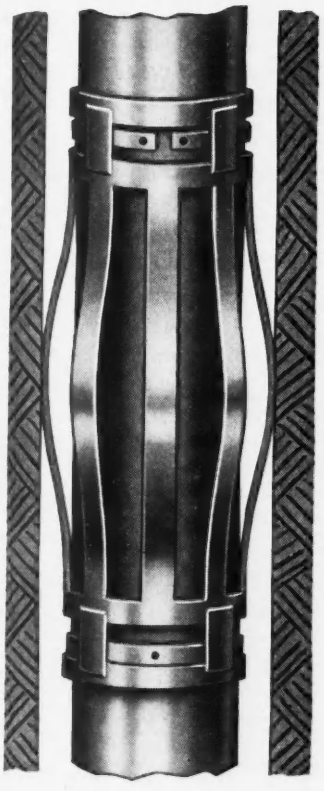
ACKNOWLEDGMENT

This article is a resume of some of the features with a few illustrations heretofore unpublished, of a lecture presented at the request of the Distinguished Lecture Committee of the American Association of Petroleum Geologists to several affiliated societies. It is not to be construed as an endeavor to interpret regional orogenies and building of continents, such as is being currently attempted by Wilson (1948, 1949). For much assistance in preparing the lecture grateful thanks are given to my colleagues on the staff of the Geological Survey of Canada.



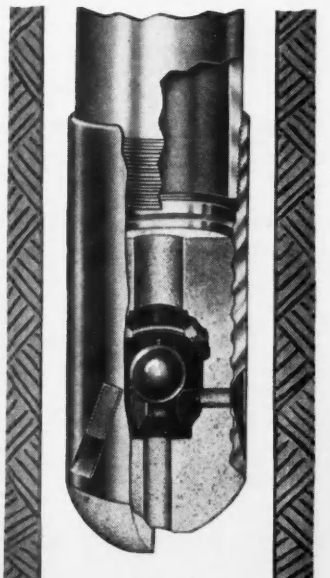


Fig. 2

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Schoonebeek-
Landscaped Oil Field

Schoonebeek's oil field is kept as inconspicuous as possible in order to preserve the rural charm of the landscape. In this view of the flat countryside, one of the pumping jacks (center) stands in a line of trees which serves to mark the boundary between two farms.

THE Schoonebeek oil field, on the border between Germany and Holland, has achieved the distinction of being the only "landscaped oil field" in the world. The field reached virtually its maximum efficient production rate of about 12,000 barrels daily in 1949, and no further active drilling program is planned.

The Schoonebeek field — largest in Western Europe—is owned by the N. V. Nederlandse Aardolie Maatschappij, a joint company composed 50 percent of the interests of Standard Oil Company (N.J.) and 50 percent of the Royal Dutch Shell Group, the operator. The company has conducted its entire field operation with a scrupulous regard for the desire of the Dutch farmers to preserve their traditional ways of life and the historic rural character of their countryside. The pumping jacks and gathering tanks in the field have everywhere been blended into the landscape by screening them with trees and shrubbery.

Schoonebeek was far removed from any railroad, and when a branch line was built to it, the rails were laid to one end of the field, clear of the farming area. There, in a waste of heathery moors, the canal barges load peat for the markets at the same time that tank cars load crude for the Shell refinery at Pernis, suburb of Rotterdam, 125 miles away. For centuries the district has been prosperous as a peat source, and peat-cutting operations proceed simultaneously with modern petroleum production activities.

The farmers' rights are surface rights. Their soil is drained swampland, spongy with peat, on which they raise rye, oats and potatoes. The oil company pays them rent for sectors of their field on which oil installations have been placed, and also compensation for crop damage and other losses they may sustain. Tank cars rather than a pipe line are used to transport crude to the refinery in order to avoid any pipe crossing the farms. Every night 60 tank cars leave the loading rack for Pernis.

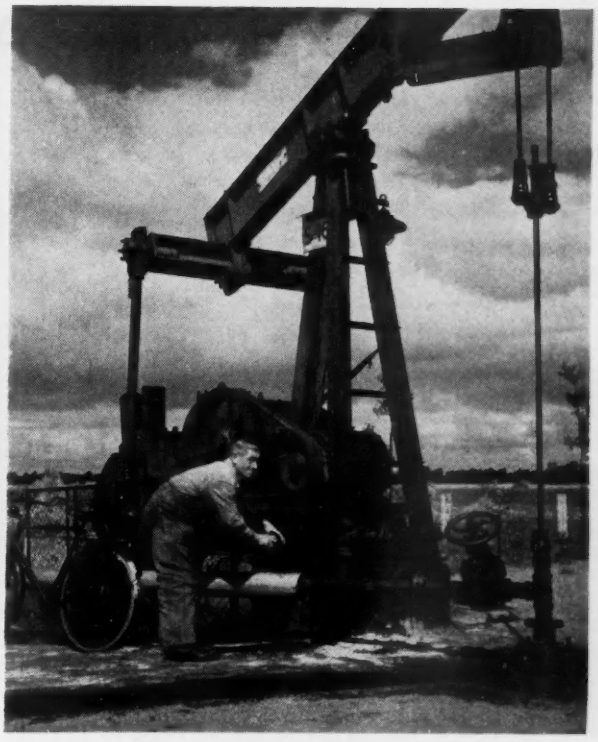
During 1949, about 3000 feet of hole was drilled in Schoonebeek and there are now 79 wells in production and two others drilling. This contrasts sharply with 1948 when 41 wells were completed. Oil comes from the Valenginian formation of the Lower Cretaceous at a depth of about 2500 feet. Production for 1949 totalled more than 4 million barrels of 24.8 gravity crude.

Geophysical work in the area began in 1935 and later 12 exploratory wells were drilled, known as the "North Netherlands Drillings." These showed a promising structure west of Coevorden where operations were carried on from 1937 to 1939. During German occupation more than 60 wells were drilled, of which only two were productive for the Nazis. These two wells were the beginning of Schoonebeek's postwar operations. In May, 1948, a concession was granted the N. V. Nederlandse Maatschappij covering areas in the municipalities of Schoonebeek, Coevorden, Dalen, Emmen, Sleen and Gramsbergen.

To date 85 wells have been drilled in Schoonebeek, of which 79 are now productive.

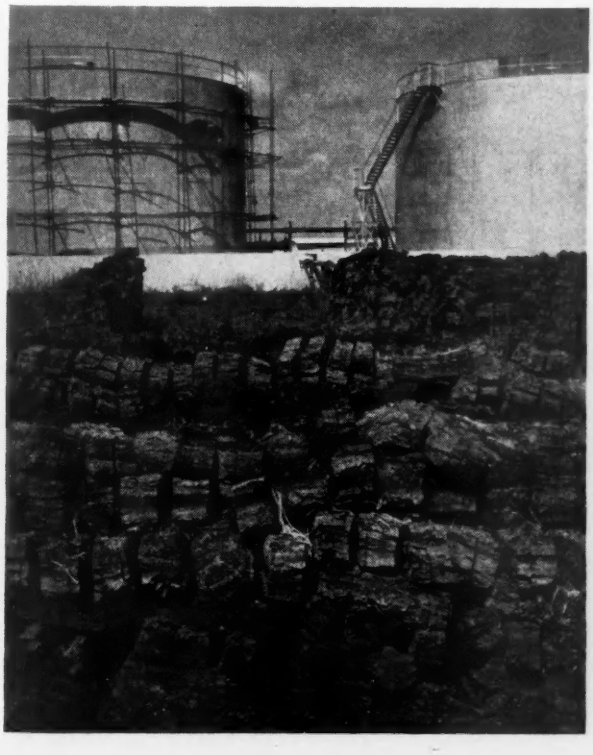
Filling two trains of 30 tank cars each, Schoonebeek's daily production of 11,000 barrels of crude leaves the loading rack every night for the refinery near Rotterdam.

The farmer's living quarters and his barn are both beneath the high-pitched thached roof of this typical Schoonebeek farmhouse.

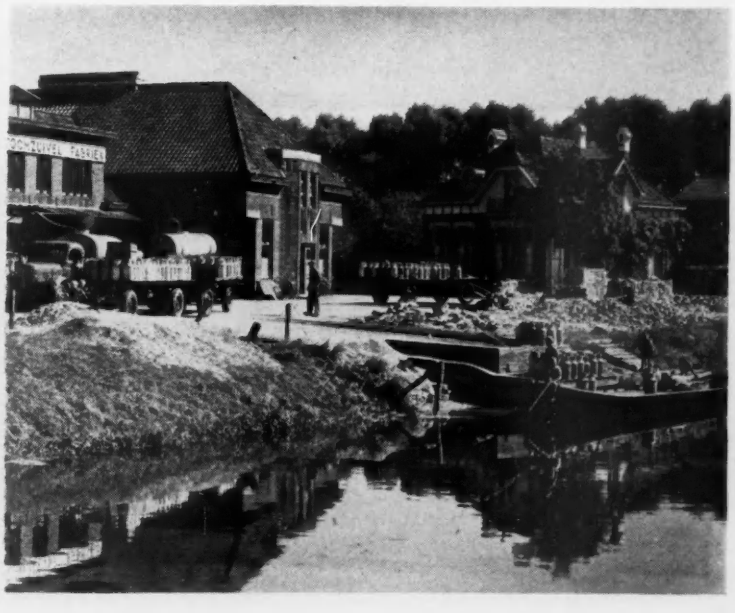


Their nodding motion has given the pumping jacks the picturesque name of "ja-knikkers," or yes-nodders. Virtually all the producing wells at Schoonebeek have to be pumped.

Side by side, the newest and one of the oldest of fuels await shipment—crude oil in the silvery tanks in the background, and peat stacked like brown bales of hay in the foreground.



Farmers on the Schoonebeek oil field dispatch their milk to the big creamery at Coevorden by tank truck, trailers and canal barges.



Exploratory Activity Renewed in

Ecuador

THE trend toward the grouping of American independents and individuals to carry on foreign oil operations is further evidenced by work now being done by Manabí Exploration Company, Inc., in Ecuador.

This company was formed to explore and develop concession areas totaling more than 2 million acres situated at geologically favorable locations along the Pacific Coast of Ecuador, and has been carrying on preliminary geological and geophysical work since the early part of 1949. A tentative location has been selected for the first test.

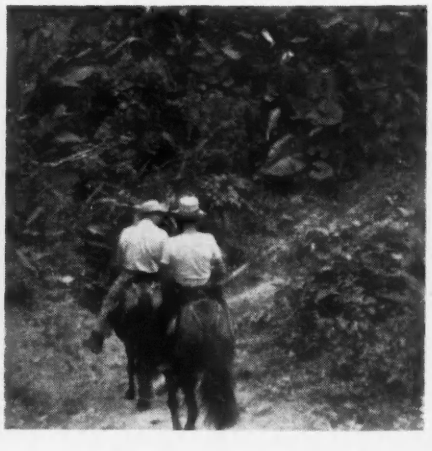
Operations in Ecuador had been, until recently, limited because of a delay in the final granting of concessions to add to those around which the firm originally was formed. This earlier block of acreage consisted of about 984,000 acres in the province of Manabí, centering about 100 miles northerly from the Santa Elena Peninsula, upon which all of Ecuador's present oil production is located. Recently, however, firm concessions were secured by the Manabí company on an additional 1,197,000 acres in the provinces of Esmereldas, Manabí and Guayas, so that a substantial part of the west coast section of Ecuador may be explored, and operations have been expanded to cover this larger area.

Concession terms call for a five-year exploration period, followed by a four-year development time allowed for building up production, followed by a 30-year exploitation term. The concessions carry provisions for granting of ten-year extensions to the exploitation phase.

The Manabí company is favorably impressed with the legislative setup which in its opinion provides petroleum laws more favorable to foreign private capital than those of any other Latin-American

Upper left and lower right: **Reconnaissance geological work in the western provinces of Ecuador is made doubly difficult by rugged country covered with tropical rainforest.**

Lower left: **Corduroy road built for transportation of personnel and equipment over swampy areas near Borbon in the Province of Esmereldas.**



country. It has also been impressed with the friendly and cooperative attitude of the country's representatives.

During the greater part of 1949 Manabí maintained four full exploration crews in coastal Ecuador. These consist of one gravity meter crew, one surface geological party, and two soil analysis crews. One feature of the preliminary exploration work has been the fact that it has been possible, because of the convenient location of concession blocks, to operate all four of the crews out of the same base and supply camp. Until recently, this base has been situated just northeast of Bahia in Manabí province. Currently the crews, still operating from the same camp, are working out of a base which has been moved southward into the province of Guayas, and detail work is being done in the area near the base of the Santa Elena Peninsula. It is planned to start the first actual wildcat drilling of this program immediately after the beginning of the dry season, probably some time in May.

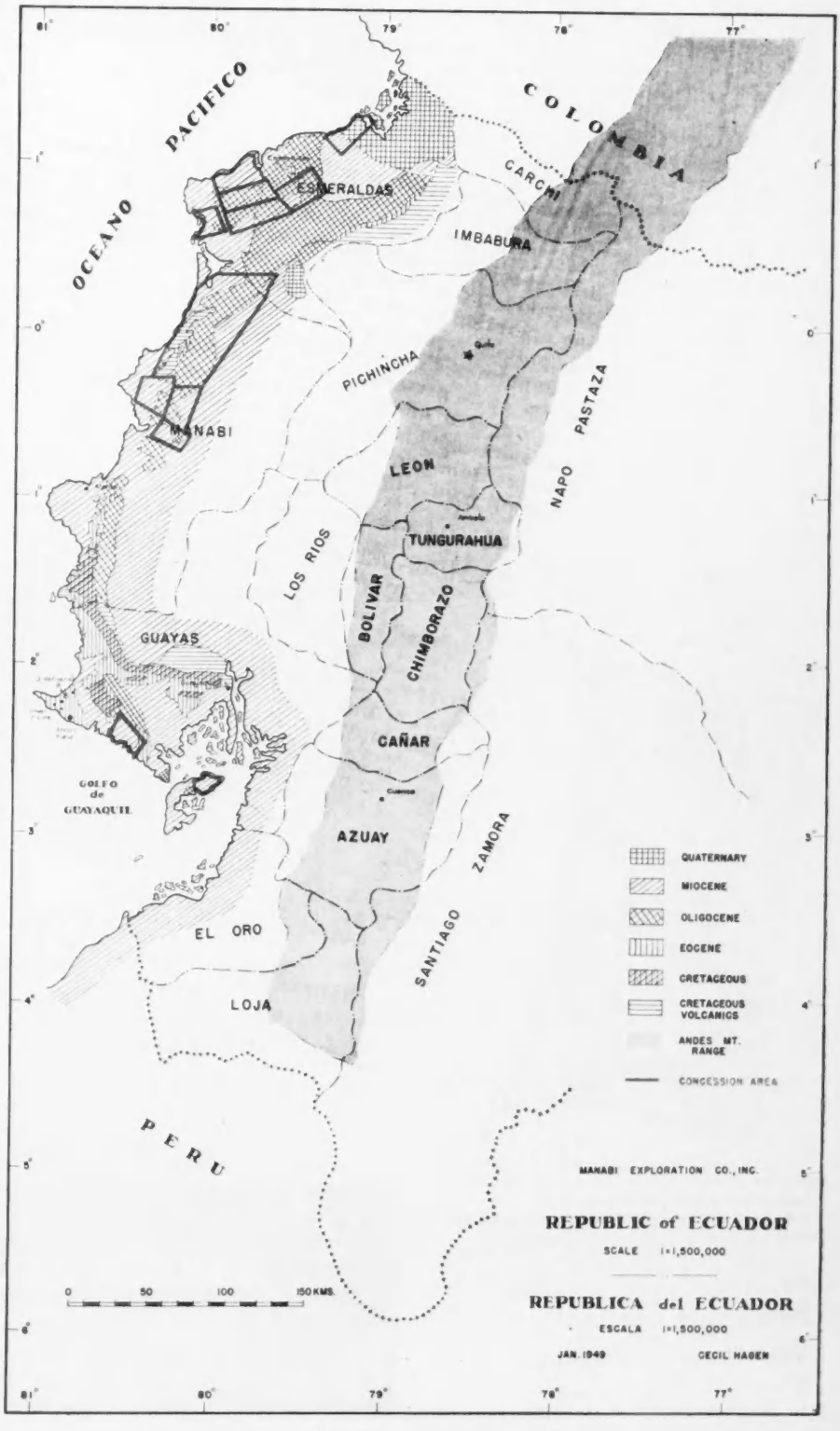
Ecuador's only oil production is from fields on the Santa Elena Peninsula, and now amounts to approximately 7000 barrels of light oil daily, all from relatively shallow depths in the upper Eocene formations. Although the central and western parts of the peninsula have been under development and investigation for many years, exploration elsewhere in the nation has been rather sparse.

The coastal zone in which the new company's concessions are located is a strip almost as long as the Gulf Coast of Texas but outside the peninsula itself, only about 20 wildcats have been drilled. The area contains three principal basins favorable for the accumulation of oil. One, known as the Progreso Basin, in the southernmost part of Ecuador, the Jipijapa-Quininde Basin in the central portion of the coastal strip, and the Borbon Basin to the north. The northern and central basins in particular have seen relatively little drilling. Only three wildcats have been drilled in the Borbon Basin and four tests in the Jipijapa-Quininde area.

The best oil possibilities in these basin areas are believed to be in the Tertiary formations where geological investigation has indicated a composite thickness in excess of 50,000 feet. In the southern portion of the coast there has been a section of sediment amounting to 13,206 feet actually proved by drilling. In this test, drilled by International Petroleum Company, the well had just reached the upper Eocene formations. Some Cretaceous has been noted along the coast, and where penetrated it is in contact with basement rock.

Notwithstanding the failure of International's series of about 20 wildcats during a six-year period to establish commercial production, it is thought by current operators that the circumstances of the campaign were such as to be inconclusive, since most of the wells were drilled under wartime conditions involving some shortage of manpower coupled with an urgency imposed by limitations of time. Most of them were drilled on the strength of relatively meager information considering the large area involved.

Manabí Exploration Company, Inc., is a Texas corporation, domiciled in Ecuador with a permit to do business in that country. It is headed by Cecil V. Hagen, consulting geologist and independent producer, Houston, as president and general manager. It is participated in by a group of strong independents and individuals, most of whom are doing business in Houston, Dallas, Tulsa and New York. Hagen has been carrying on geological work in Ecuador periodically during the past ten years.



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Contaminants flocculate ordinary drilling muds. Flocculation causes high water loss, which may result in stuck drill pipe, fishing jobs, loss of hole. This unhappy cycle plagues many a drilling operation in which the mud carries no protection against contamination.

Impermex, Baroid's organic colloid, gives such protection by preventing the adverse effects of cement, salt, gypsum, anhydrite, and other drilling mud contaminants. Impermex provides drilling mud with extraordinarily low water loss—as low as 1 cc. A.P.I. in many cases, and easily controllable viscosity and gel characteristics. Thus, no matter what the drilling conditions, Impermex makes any clay mud a superior mud.

Drilling, particularly in deep wells, presents enough problems without the additional hazard of an unprotected drilling mud. Records show hundreds of modern operators protect their wells with Impermex when the going gets tough.

SOUTHERN OKLAHOMA . . .
CASE XXX

On this well, drill stem tests from the Simpson recovered several thousand feet of water contaminated by salt and sulphur compound, and the clay-water mud became badly contaminated, resulting in a very high water loss. This mud was treated with alkalizing agents and Impermex over a 12-hour period.

	Contaminated Mud	Same, after treatment
Weight	10.0 lbs. per gal. (75.5 lbs.cu.ft.)	10.0 lbs. per gal. (75.5 lbs.cu.ft.)
Viscosity	50 sec. API	43 sec. API
Water Loss	52 cc API	1.8 cc API
Salt	1.7% by weight	. . . .
Cake Thickness	. . . .	1/32" API
pH	7.9	12.5

Caving of the Pennsylvania shales stopped at once; tight hole in porous zones was overcome, and the well was carried 2000 feet deeper with no trouble.

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FOREIGN VISITORS attending the January meeting of Houston Nomads, shown left to right: D. V. Smith, Reynosa, Mexico; W. D. Koonze, Bogota, Colombia; T. R. Whittaker, Anglo-Saxon Oil Company, London; W. J. Nifelt, B. P. M., The Hague; Helmy Elmasri, Anglo-Egyptian Oilfields, Cairo, Egypt; C. R. Summers, Caracas, Venezuela, and O. L. Nuernberger, Houston. Officers elected for 1950 will be installed at the annual dinner dance at the Shamrock Hotel January 27. They are Edmond L. Lorehn, Cameron Iron Works, president; Wayne Rives, *Oil and Gas Journal*, vice president; Tracey T. Word, Jr., Well Equipment Manufacturing Corporation, secretary-treasurer; E. F. (Salty) Baldwin, Hughes Tool Company, assistant secretary-treasurer; Lawrency J. Kelley, Hillman-Kelley, sergeant-at-arms; C. F. (Bud) Vincent, Byron-Jackson Company, deputy sergeant-at-arms; and E. M. Fontaine, National Tank Company, and C. B. McDonald, A-1 Bit and Tool Company, regents.

Egyptian Government Conducts Extensive Exploration Program

The Egyptian government is prepared to begin this year what it describes as the widest and most extensive search ever conducted for oil in that country. It will operate through an all-Egyptian firm, National Petroleum Company of Egypt, which has been granted a concession covering 267,000 acres.

Torcom Papazian, managing director of the company, will visit the U. S. this spring for equipment which will cost more than $4 million. Drilling operations will start on both sides of the Gulf of Suez, he said, and on the Sinai Peninsula, in both of which areas American companies have operated previously. In addition, Egypt will drill at Sollum, near the country's northwestern frontier with Cyrenaica, as well as in the Fayoum area south of Cairo. Both of these latter regions are regarded as rank wildcat territory.

Papazian said "preliminary geological surveys forecast an important oil stratum. If our calculations are correct, we hope in four years to produce enough oil to triple Egypt's present output of crude."

The formation of the all-Egyptian company is viewed as a local answer to the reaction of American companies which lost much interest in Egypt last year following passage of highly restrictive legislation. Standard Oil Company (N.J.) subsidiary, Standard of Egypt, quit operations, and it is understood that the joint venture of the British Anglo-Egyptian Oilfield, Ltd., and Socony-Vacuum, in the Sinai Peninsula, is endangered by the present legislative curbs. Egypt on a number of occasions has displayed hostility to foreign operations within its borders, and the present move is deemed an attempt to "take the ball from the foreign companies." The Egyptian National Company was launched with a capital of $78,000, but this amount is being raised to $2,780,000. The company emphasizes it will have no ties with either British or American firms.

Whatever oil National finds will be refined at the Egyptian government plant at Suez until internal requirements are satisfied.

Pakistan Well Yields 1692 Barrels After Acidization

The recent oil discovery in Pakistan by the Burmah Oil Company in its No. 2 well at Chakwal, West Punjab, is currently yielding 1692 barrels a day after acidization, according to the Pakistan government's Petroleum Directorate. The pocket struck by Burmah Oil "is not estimated to be any larger than the ones operated by the Attock Oil Company, Ltd., and an optimum of 2000 barrels a day is expected," official announcement said.

Burmah Oil at Lakhra has drilled to a depth of 10,706 feet and was prepared to go to 14,000 feet in its new test. Results of this test, the government hoped, will enable estimates of the underground reserves of West Pakistan over and above those of Potwar area in which the Balkassar and Chakwal fields lie. Drilling is not yet planned for East Pakistan.

The government announcement added: "Regarding drilling equipment required, the oil companies presently prospecting in Pakistan have sufficient for immediate requirements. The question of the government taking over this phase of activity is a matter yet to be determined. As to refinery equipment needed for the future, much depends on the finds and their sizes. If oil is found in sizeable quantities a refinery will be erected at Karachi."

ENGINEER-WRITER WANTED

WORLD OIL has an opening on its editorial staff for an engineer or geologist who also has the ability to write.

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Want young man well-grounded in principles of oil field practices, equipment and operations, with some subsequent practical oil field experience. Not necessary to have had experience with any magazine, but should have written considerable engineering reports or papers—and MUST LIKE TO WRITE. In addition must have good personality, as ability to meet people and obtain information from them is highly important. Use of camera and typewriter also required.

Duties consist of contacting oil men to obtain information for articles, and writing publishable stories on domestic or foreign operations, politics or economics. Work includes combination of office and travel. Location in Houston, with travel to various foreign and U. S. oil centers.

State education, age, oil field experience, writing experience, and salary expected above traveling expense.

Address: The Editor, WORLD OIL, Box 2608, Houston 1, Texas.

Wells Drilled, Depth Total Doubled in Alberta in 1949

IN ALBERTA, where more than 90 percent of western Canada's drilling activity was concentrated during 1949, more than twice the number of wells were completed in 1949 than in 1948. The past year saw 820 wells drilled to compare with 366 wells in the record year of 1948. These included 244 wildcats and 576 development wells and resulted in the addition of 565 oil wells, 34 gas wells and 221 dry holes. The total footage represented in these wells amounted to more than 25 percent of all footage ever drilled in the province. The 1949 total of 3,273,000 feet of hole boosted total cumulative footage to 12,227,000 feet drilled since the beginning of oil exploration in Alberta.

The wildcatting program, although resulting in many dry holes, was extremely successful in that it opened, through discovery of new fields, and expansion of existing fields, more than 650 million barrels of new reserves. At the beginning of the year Alberta economists estimated the reserve of the province at 550 million barrels. At the close of the year it was estimated at 1.2 billion barrels. The Redwater field, discovered late in 1948, developed into Canada's greatest single reserve during the year with a total of 271 producing wells and a reserve estimated at 600 million barrels from the Devonian D3 formation. The Leduc field now has 347 producing wells and a reserve of more than 250 million barrels.

New discoveries for the year include oil from the Devonian at Normandville, 200 miles northwest of any previous production, and paved the way for exploration into vast new areas. Also during the year Devonian oil possibilities were expanded 100 miles southeasterly from Leduc by discovery of D2 and D3 pay at Stettler. Other discoveries included oil from Cretaceous at Casagama near Stettler, Devonian discoveries at Golden Spine, Bon Accord and Excelsior, and Cretaceous discoveries at Whitemud and Campbell. The first oil production from the Viking sand was found at Joseph Lake. Madison limestone production was found at Barrhead and expanded at Pincher Creek.

At the close of the year more than 125 million acres of land were under exploration or development permits in western Canada, about double the amount under lease at the beginning of the year. About 60 million acres were located in Alberta and a like amount in Saskatchewan, with the remainder in active areas of Manitoba and British Columbia.

Geophysical activity during the year climbed to a peak of 110 crews as compared with 65 crews in 1948 and 22 in 1947. It is likely that the huge amounts of acreage under commitment will cause new peaks of such activity during the coming year.

Canada Abandons Experimental Work on Tar Sand Deposits

The Canadian government, in view of increasing supplies of oil from flush producing fields in central and southern Alberta, has abandoned its six-year experiment involving the exploitation of the huge tar sand deposits at Abasand in northern Ablerta. The development started a number of years ago as a private venture, but was taken over by the government during wartime shortages. The results to date have apparently not been encouraging enough to justify the continued outlay of public funds as a peace-time project.

Alsatian Discovery Indicates 560-Barrel Daily Production

A considerable amount of interest has been aroused by a well near Pechelbron in Alsace, which indicated a potential steady production of more than 560 barrels daily from a formation which has not hitherto been productive in France.

The discovery, situated about 11 miles north of the town of Haguenau, was drilled by the S. A. d'Exploitations Minieres Pechelbronn near Soultz-sous-Forêt. At 2850 feet the well came in as a gusher, producing an estimated 6500 barrels of light oil daily, but was quickly brought under control and produced at the rate of 560 barrels daily under pressure of 3500 pounds per square inch.

This well is of particular interest, since the producing sand is in the formation locally known as the Muschelkalk, and this is the first time a wildcat has been drilled in this region to a point below the Tertiary. It opens up new possibilities for the entire area. The Muschelkalk is a regular formation; broken by long faults, and offers possibilities for accumulation over a trend of considerable length.

Colombian Oil Legislation Bids for Renewed Activity

BY EXECUTIVE decree Colombia promulgated in January its long-awaited new petroleum legislation in an effort to attract American oil companies to renewed activity in that country. The law, which was proclaimed by President Mariano Ospina-Perez, must receive approval by the Colombia congress when it reconvenes; but so urgent is the need to bolster the country's oil economy that Dr. Mariano Ospina decided to act while the congress is adjourned during the current state of siege.

The law was received with mixed feelings by industry representatives who studied it in the U. S. Many felt that the provisions did indicate a desire on the part of the Colombian government to woo rather than frighten foreign operators, but the concensus was that the legislation is still inadequate in several respects.

The principal features of the new law:

- All exploration work will be exempt from the former "patrimony tax," which was a capital levy on exploration expenses.
- The producing companies are granted a depletion allowance for income tax purposes. This allowance may be computed on a fixed 10 percent of gross production basis, or on a "technical estimate"; but in no case can the allowance exceed 20 percent of net income calculated after the allowance itself.
- Companies are allowed tax deductions on the cost of exploration work carried on in other areas, but not to exceed 5 percent of total exploration investment in all areas. This exemption stops as soon as production begins on the area in question.
- Concessions must be of specified geometrical shape, and length cannot exceed 2½ times the width.
- Three months after a company receives an approved lease, the company must sign an exploration contract. (Drilling requirement is retained from the old law: first drilling must begin within 2½ years after signing of the contract.)
- Rental fees are raised. In the area east and southeast of the eastern branch of the Andes, the rental rates are now set as follows: 10 cents per hectare (2.47 acres) for the first and second year, 20 cents for the third year, 30 cents for the fourth year, 40 cents for the fifth year, and 50 cents for the sixth year on. All royalty and rental figures are in Colombian currency.
- During the exploitation period surface rental will be one-half of what it was the year before production started. This applies to the region covered in provision above.
- For all other areas of Colombia, surface rentals are as follows: 10 cents per hectare for the first year, 30 cents for the second year, 50 cents for the third year, 70 cents for the fourth year, 90 cents for the fifth year, 1.20 pesos for the sixth year, 1.50 pesos for the seventh year, 2 pesos for the eighth year, 2.50 pesos for the ninth year, and 3 pesos as soon as production starts.
- Royalty schedules are as follows: On production obtained up to 100 kilometers from the coast, 13 percent of gross output; with the following sliding scale thereafter:

200 kilometers	12 percent
300 kilometers	11 percent
400 kilometers	10 percent
500 kilometers	9 percent
600 kilometers	8 percent
700 kilometers	6 percent
800 kilometers	5 percent
900 kilometers	4½ percent
More than 900	3 percent

One kilometer equals .62 mile.

On fixing the royalty schedule, intermediate distances shall be proportional to the zone percentages, excepting that any offshore concession will have a flat 10 percent royalty rate. Natural gasoline and gas rates are fixed at the same scale.

Any company can surrender its concession at any time, without drilling, providing that it can prove to the Colombian Minister of Mines that there is no probability of oil discovery on the concession.

The law also provides for unsnarling much of the red tape which has surrounded title clearing, especially relating to those lands to which title was held by private owner prior to 1873. Under the new procedure, such cases will go directly to the Colombian Supreme Court and litigation time will be cut from a matter of years to several months.

Insufficient Crude Oil Causes Shut-Down of Haifa Refinery

The Haifa plant of Consolidated Refineries, Ltd., has again shut down due to a lack of crude oil, and indications are that the current shut-down will continue until such time as some of the differences between Middle Eastern interests are resolved. The plant, normally supplied by the Iraq Petroleum Company's line from the Kirkuk field in Iraq, has been cut off from that source since April, 1948 when the Iraqi government refused to allow deliveries through the liine to Israel. In the meantime Egypt refused passage through the Suez Canal of tankers bound for Israel with Persian Gulf crude. A limited supply of crude oil from Venezuela which has kept one of the refinery's units working on part capacity since October, but this uneconomic operation has now been halted.

Chile's Spring Hill Field Has 16 Producers from 29 Tests

Chile's Spring Hill field (Cerro Manantiales), on Tierra del Fuego island at the southern tip of South America, now has 16 oil producing wells out of 29 which have been drilled. This was disclosed by German Pico Canas, vice president of Chilean Development Corporation, who reported that Chile "has now completed the first phase of its oil industrialization program, just four years after the first discovery."

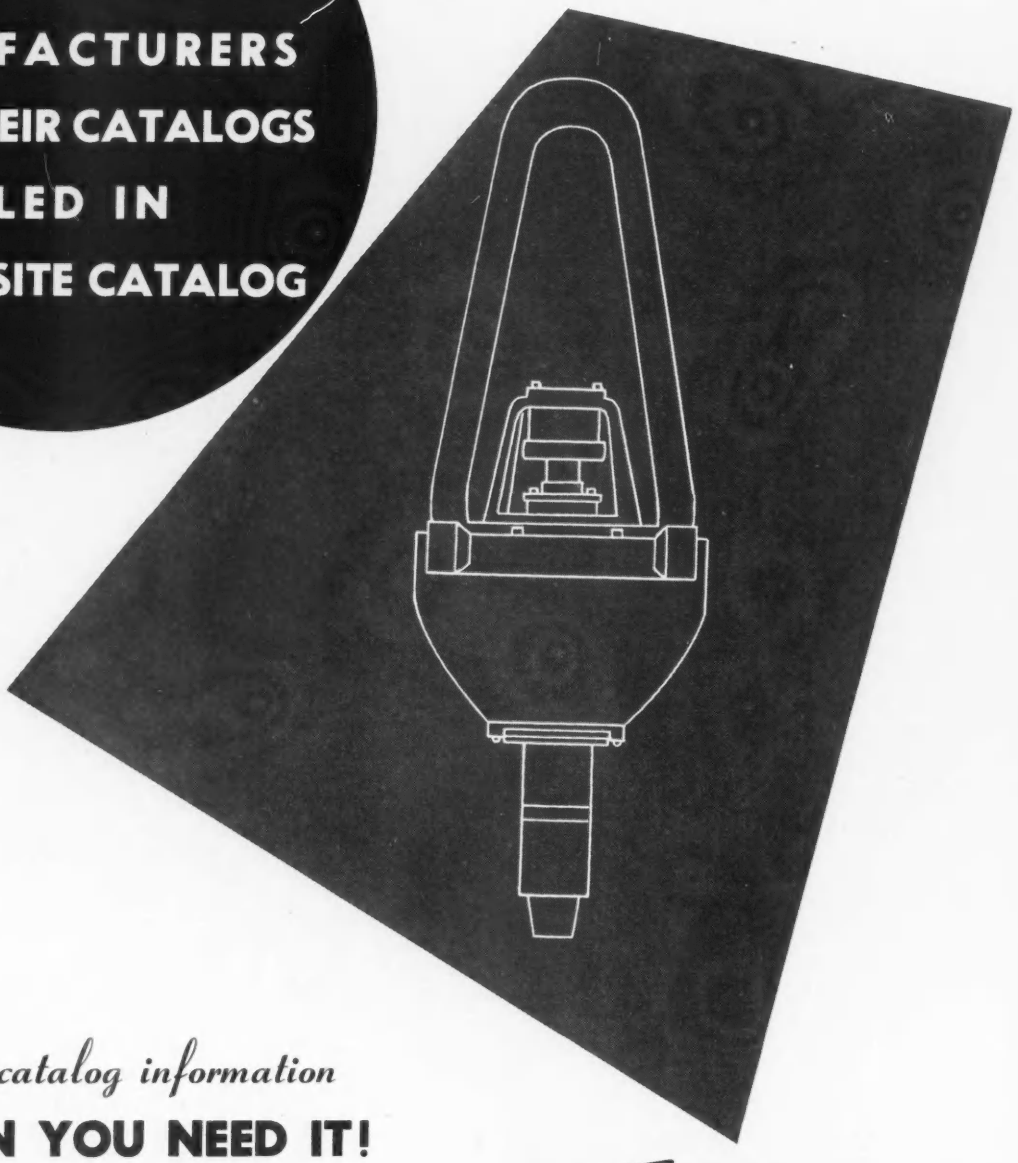
He said the field development represented an investment of 550 million pesos to date. The crude oil line connecting the field with the terminal a Caleta Clarencia on Gente Grande Bay, Straits of Magellan, is operating, he said, and 65,000 barrels of crude already are stored in the Spring Hill field tanks. The Caleta Clarencia tanks, with a present capacity of 600,000 barrels, are now being filled.

Canas revealed that an agreement has been reached with Administracion Nacional Combustibile Alcohol y Portland (ANCAP), Uruguayan state petroleum monopoly, for the purchase of $2 million worth of Chilean oil during 1950. Shipments, he said, will begin in mid-February when the President of Chile formally opens the pipe line.

Chile is also conducting negotiations with Argentina, and a contract may soon be drawn for sale of Chilean oil to Argentina. This contract may wait on increased Spring Hill production, now about 2000 barrels daily, but which can be increased to about 10,000 barrels a day, Canas said.

Construction of a refinery will begin this year, and nationally-produced natural gas will be distributed inside Chile by the end of 1952.

18 DRILLING SWIVEL MANUFACTURERS HAVE THEIR CATALOGS FILED IN COMPOSITE CATALOG



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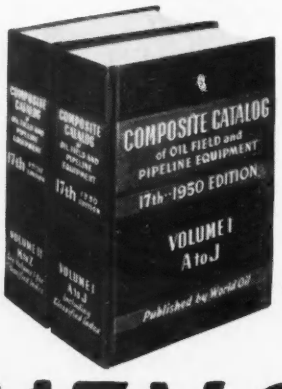


THE UNIVERSAL EQUIPMENT GUIDE FOR OIL COUNTRY BUYERS

COMPOSITE CATALOG

DESCRIPTIONS OF NEW EQUIPMENT IN THIS ISSUE OF WORLD OIL ARE SUPPLEMENTS TO THE MANUFACTURERS' PRE-FILED CATALOGS IN COMPOSITE CATALOG

NEW AND IMPROVED EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

32—Bottom Hole Cutter

This item supplements McCullough Tool Company data as shown on pages 3137-3172 of Composite Catalog, 17th Edition.

A new jet bottom hole cutter destroys or fragmentizes lost articles in the bottom of a well or articles that are plugging or obstructing progress in an oil well. The cutter focuses detonating gases to a beam, vertically, so that when the tool is positioned directly over an object or piece of junk in a well, the jet will cut the object into pieces that can be drilled up, recovered, or pushed into the wall of the well bore. It is arranged to be run with the McCullough electric service truck and to be fired from the electric control panel in the truck.

The cutter is made of aluminum alloy and consists of a case, firing head, and shock absorber. The body of the tool contains a charge of high explosive material so arranged and shaped that it creates a high velocity jet when it is detonated. The aluminum parts of the tool are expendable and disintegrate in the well, but the steel parts (sinker bar, centralizer, and firing head) are pulled from the well on the electric conductor cable on which the tool is run.

For addition information, write McCullough Tool Company, 5820 South Alameda Street, Los Angeles 11, *referring to* WORLD OIL *item* 32.

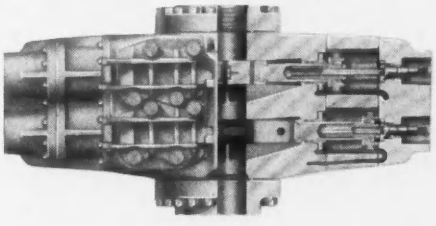
33—Hydraulic Gate

This item supplements Shaffer Tool Works data as shown on pages 4433-4496 of Composite Catalog, 17th Edition.

Two separate ram compartments are unitized into one body in the new hydraulic cellar control gate. Over-all height of the gate is less than 30 inches in sizes up to 13⅜ inches.

Ram assemblies are accessible through side doors hinged to the gate body. In changing rams, the old ram blocks and rubbers are removed, and new ones are inserted through the side door, which is then closed and bolted.

No moving parts project from the gate, and all moving parts in the hydraulic cylinder, including piston ram shafts, are completely enclosed. Operating parts are made of stainless steel or manganese bronze; consequently, water can be used as the operating fluid,



although hydraulic oil is recommended.

Rams travel on guide ribs raised above the sloped bottoms of the ram compartments, permitting mud and sand to drain back into the well from the gate body. Ram blocks and rubbers are interchangeable with the company's mechanically operated gate's blocks and rubbers.

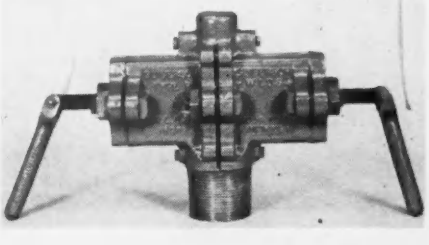
For additional information, write Shaffer Tool Works, Brea, Calif., *referring to* WORLD OIL *item* 33.

34—Wire Line Oil Saver

This item supplements The Guiberson Corporation data as shown on pages 1945-1996 of Composite Catalog, 17th Edition.

The type "R" wire line oil saver is made in two halves with only two bolts to insert and tighten. The body is cast of malleable iron and the mating surface of each half is surface-ground, effecting a metal-to-metal seal which eliminates need for gaskets.

Safety handles fold down when not in use, and are connected to the screw by a heat-treated pin. Handle, screw, plate and shoe are assembled as a unit and



new rubbers can be inserted by removing two bolts on each side.

The tools can be used singly, in pairs, or in stacks of three to clean oil, water, paraffin and muck from the wire line.

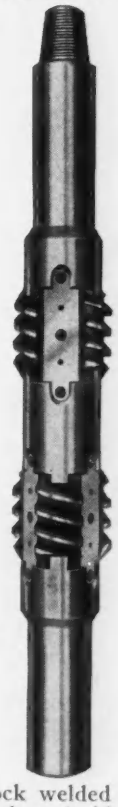
The rubber used in the type "R" is a new compound resistant to oil. Replacement is accomplished by inserting a new rubber behind the old one, so that each rubber can be used completely.

For additional information, write The Guiberson Corporation, P. O. Box 1106, Dallas 1, *referring to* WORLD OIL *item* 34.

35—Casing Scraper

This item supplements Baker Oil Tools, Inc., data as shown on pages 489-592 of Composite Catalog, 17th Edition.

Gun-shot burrs, imbedded bullets, cement or mud sheath and similar obstructions on the inside walls of the casing can be removed with the Roto-Vert casing scraper. The Roto-Vert is used to supplement the Baker Model "B" casing scraper, where it is desired to scrape away the mud sheath from top to bottom of the hole and/or where a large number of gun-shot burrs are to be removed.



Six blade blocks are mounted on the body and held in position by blade block retainers. The blade blocks are set in two horizontal rows in staggered position so that the scraper blades overlap and assure effective scraping of the 360-degree inside wall surface of the casing. Blades are cut on a helix angle for a scraping or shearing action both while moving down the hole and while rotating. The thrust of each blade block, during rotation, is taken by a driving block welded to the body. Springs behind each blade block hold the hard-faced scrapper blades against the inner wall of the casing.

The scrapper can be run on drill pipe, tubing, or a wire line.

For additional information, write Baker Oil Tools, Inc., P. O. Box 2274, Terminal Annex, Los Angeles, *referring to* WORLD OIL *item* 35.

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Thermoid
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Tube—Synthetic rubber . . . abrasion and oil resistant . . . free circulation and long life assured.
Reinforcement—Steel cables and pre-stretched fabric for the greatest strength and flexibility.
Cover—Special vulcanized compound resists aging and abrasion.
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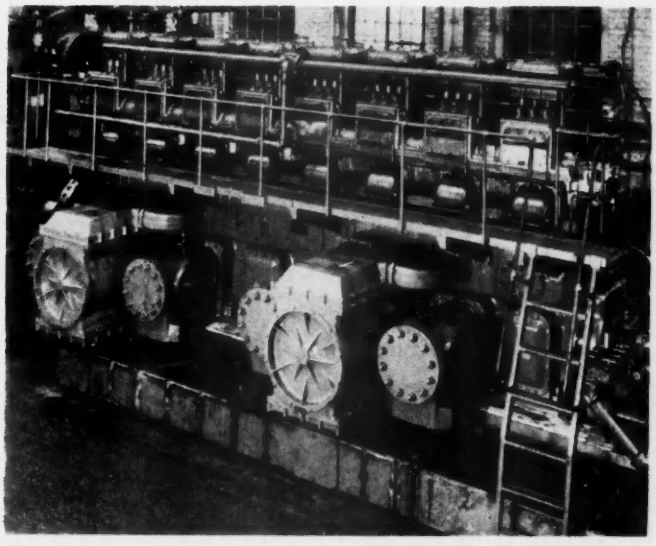
Western Offices and Factory • Nephi, Utah, U.S.A.
Main Offices and Factory • Trenton, N. J., U. S. A.
Industrial Rubber Products • Friction Materials • Oil Field Products

36—Gas Engine Compressor

This item supplements Worthington Pump and Machinery Corporation data as shown on pages 5145-5164 of Composite Catalog.

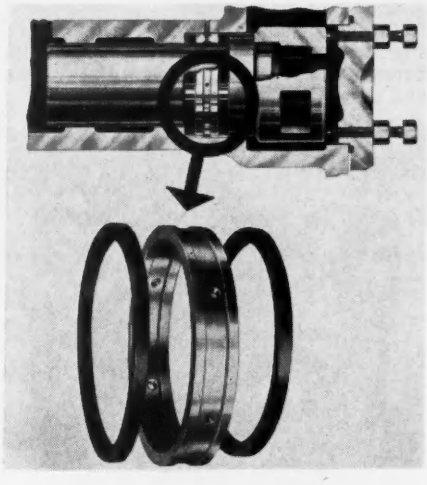


The new Uniflo gas engine gas compressor for transmission lines uses the scavenging principle. Air inlet ports around the entire circumference at the bottom of the cylinder and dual, mechanically operated exhaust valves at the head produce clearance of burnt gases from the cylinder. The system assures complete charging with clean air, extremely low exhaust temperatures and assured load carrying ability.

For additional information, Write Worthington Pump and Machinery Corporation, 426 Worthington Avenue, Harrison, N. J. *referring to* WORLD OIL *item* 36.

37—Liner Packing

This item supplements Oil Well Manufacturing Corporation data as shown on pages 3685-3704 of Composite Catalog, 17th Edition.



Two sealing rings separated by a steel lantern ring comprise the Red-Devil Tell-Tale liner packing. Leakage can be detected immediately at the "tell-tale hole" drilled through the cylinder in line with the center groove of the lantern ring. Liners can be replaced before fluid cuts in pump cylinder can occur.

Lantern rings are machined from steel forgings and are processed against corrosion. Molded sealing rings are resistant to oil, gas, acids and most chemicals.

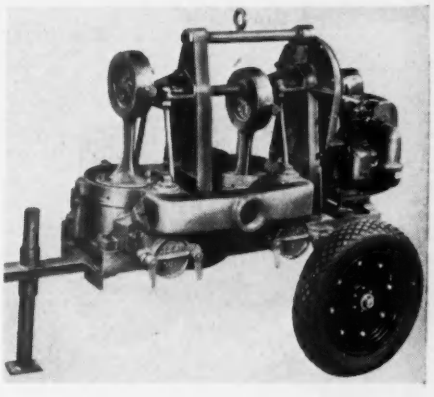
For additional information, write Oil Well Manufacturing Corporation, 6000 South Alameda Street, Los Angeles, *referring to* WORLD OIL *item* 37.

38—Diaphragm Pump

This item supplements Novo Engine Company data as shown on page 3625 of Composite Catalog, 17th Edition.

A new double diaphragm pump will handle muddy or sand and debris-laden water with a constant flow, as one diaphragm pumps while the other discharges. The new pump is similar in construction, engineering and design to the company's single diaphragm model.

For additional information, write Novo Engine Company, Lansing, Mich., *referring to* WORLD OIL *item* 38.



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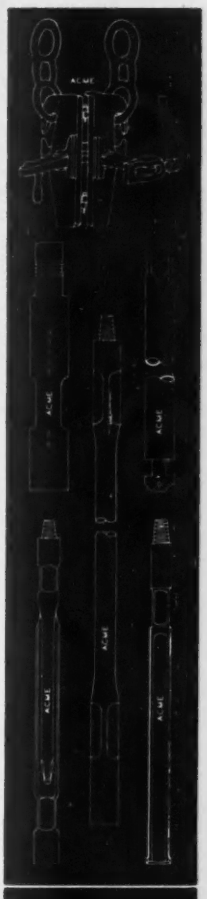
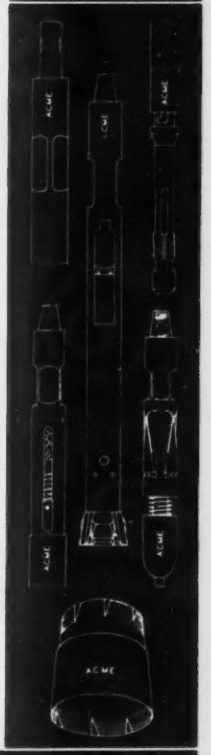
It just has to be a mighty good product . . . whose maker has stuck to it so long. As a world-market leader, Acme still specializes in:

DRILLING and FISHING TRUSTWORTHY Cable Tools





See Acme's latest condensed Catalog and tool-use Manual in Composite Catalog (up front—in Vol. 1). Or mail penny postal TODAY for your copy. Cover-to-cover full of valuable information for Cable Drillers.

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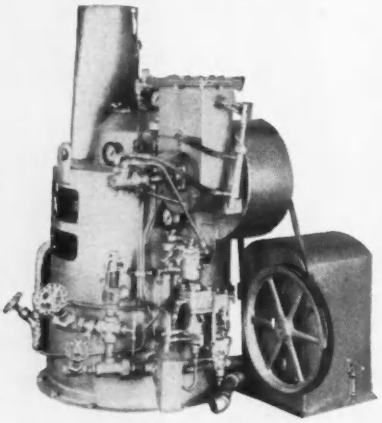
NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

39—Steam Generator

This item supplements Bettis Corporation data as shown on pages 670-674 of Composite Catalog, 17th Edition.



A ready source of steam on power drilling rigs is provided by a new automatic steam generating unit, the Bettis 15-horsepower Steamer.

Used for heat where open flame is prohibited and for steam cleaning tool joints and equipment, the unit generates 300 pounds steam pressure within three minutes after being started and will automatically maintain any selected pressure up to this maximum. It can be fired with gas or fuel oil.

Incorporated in the design is a separate two-cylinder, enclosed water feed pump, combination automatic water and fuel controls and an automatic air damper.

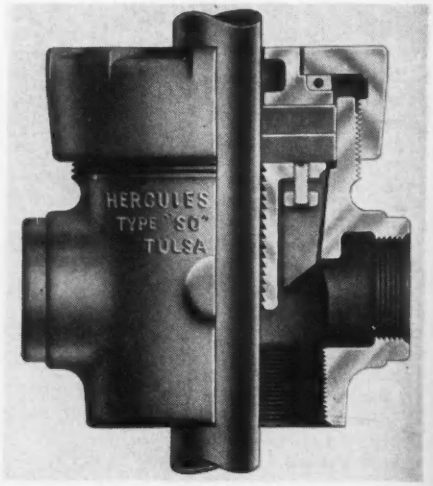
For additional information, write Bettis Corporation, P. O. Box 9091, Houston 11, *referring to* WORLD OIL *item* 39.

40—Tubing Head

This item supplements Hercules Tool Company data as shown on pages 2204-2206 of Composite Catalog, 17th Edition.

All size parts of a new stripper tubing head will interchange with all size heads. The top section containing slips and over-head packing can be interchanged with the tubing stripper in the bottom section. The head is made in 4½ to 7-inch outside diameter casing sizes and will support 2, 2½ or 3-inch plain or upset thread tubing.

Two strippers may be used simultaneously, and the bottom section may be used as a tubing head by inserting slips and packing to lower section. Slips are one-piece hinged units.



For additional information, write for Bulletin No. 229-SOS, Hercules Tool Company, Box 286, Tulsa, *referring to* WORLD OIL *item* 40.

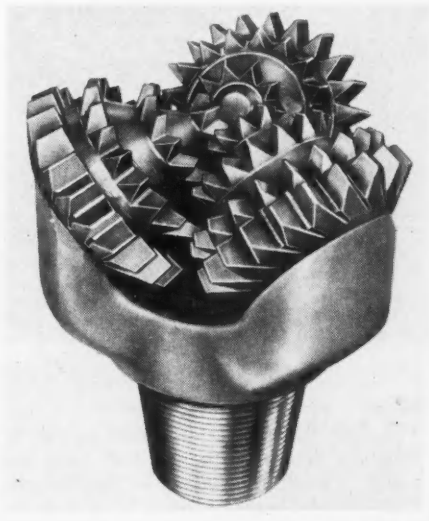
41—Rock Bit

This item supplements Chicago Pneumatic Tool Company data as shown on pages 1180-1183 of Composite Catalog, 17th Edition.

The new Type EH three-cone rock bit is for use in harder rock formations, such as dolomite, granite, chert, quartz and dense sharp sands. Teeth of the bit are closely spaced for maximum chipping action.

The reinforced gauge teeth maintain true diameter full gauge hole. Cones are set at an angle for effective rolling and crushing action, with a minimum of sliding.

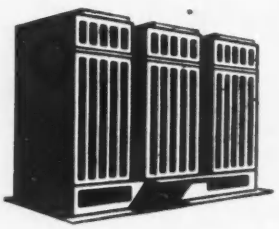
For additional information, write Chicago Pneumatic Tool Company, 6 East 44th Street, New York 17, *referring to* WORLD OIL *item* 41.



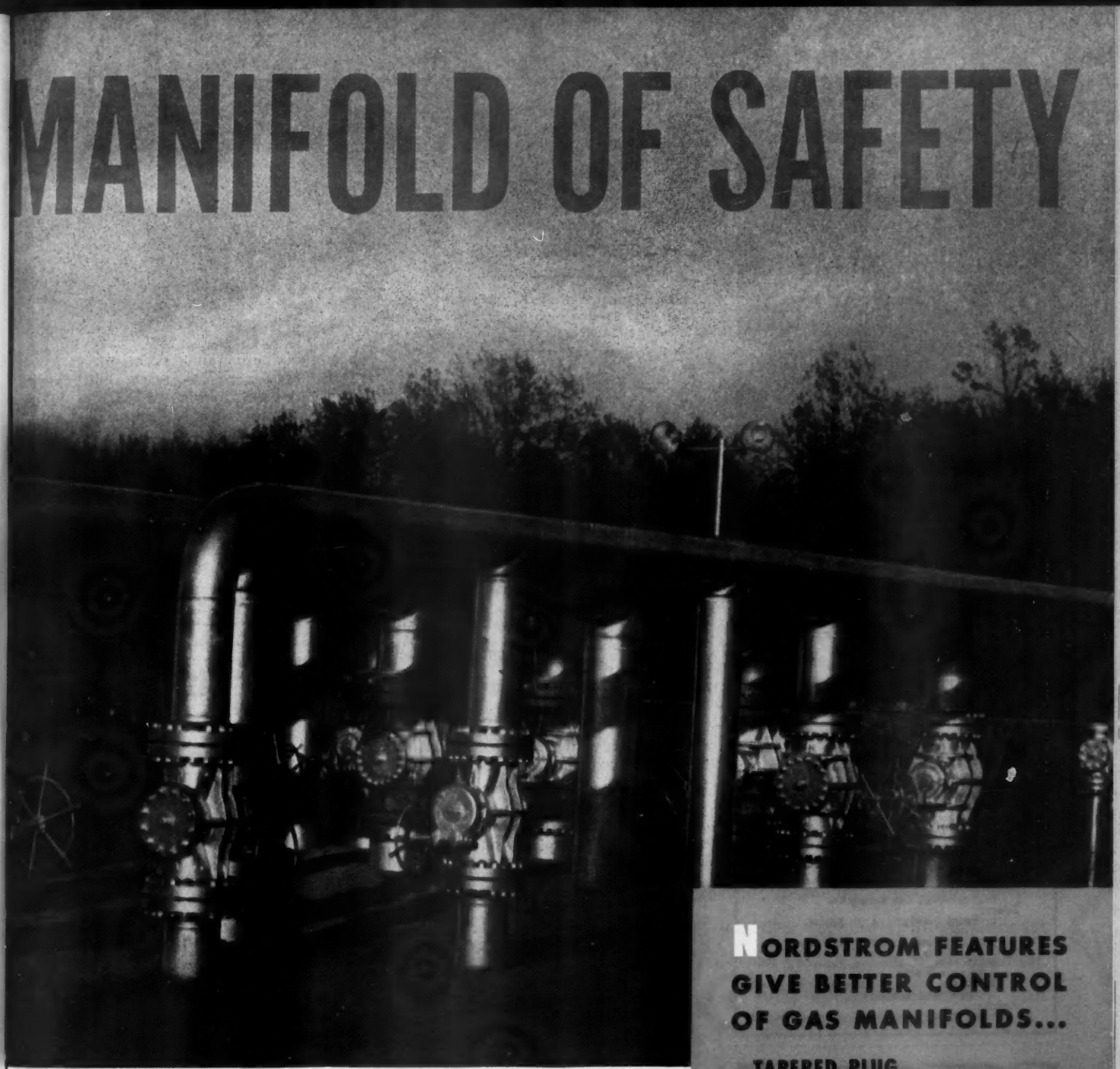
SKIRVIN HOTELS

Welcome to the Skirvin Oklahoma City

One Of The Nation's Traditionally Fine Hotels.



MANIFOLD OF SAFETY



Satisfactory manifold operation demands quick switching, absolute certainty of full closure and ease of operation. When you install Nordstroms you can set your mind at ease—they give you every advantage of speed in operation and 100% safety. *Keep upkeep down.*

NORDSTROM FEATURES GIVE BETTER CONTROL OF GAS MANIFOLDS...

- **TAPERED PLUG** —*for constant seating.*
- **PRESSURIZED LUBRICATION** —*for positive sealing, ease of turning and jacking of plug.*
- **UNEXPOSED SEAT** —*for protection from line fluids.*
- **REPACKABLE UNDER PRESSURE** —*for avoiding line shut-down.*
- **MOST COMPACT DIMENSIONS** —*for close setting in limited space.*
- **POSITIVE ROTARY ACTION** —*for certainty of action.*
- **SIMPLE QUARTER TURN** —*for quickest operation.*

...and now

- **HYPERMATIC LUBRICATION** —*for continuous lubrication and reduced maintenance.*

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(Hydrostatic)
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A QUICK, POSITIVE LOAD REGARDLESS OF FLUID LEVEL.
Ideal also for fishing small objects—widely used for drilling in (completing) wells, and for drilling cement or plastic plug everages.

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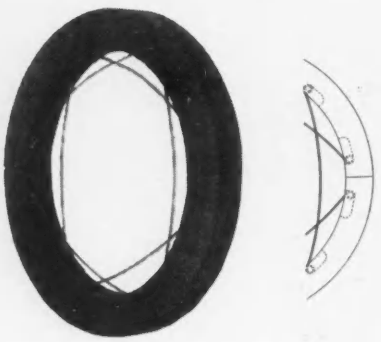
NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

42—Segmental Rings

This item supplements L. K. Pump Valve Company data as shown on pages 2826-2831 of Composite Catalog, 17th Edition.



Two new types of segmental rings and expanders—the Pres-Rite Single Segment and the Pres-Rite Double Segment—are designed for use on pumps and compressors. Illustrated is the double segment type with short section, showing end of expander fitted into socket.

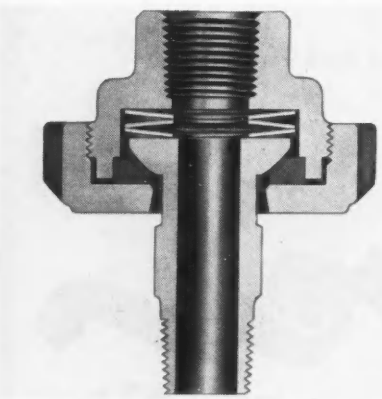
Stainless steel spring wire fitted into sockets or grooves in the segments makes possible uniform pressure to each expander. Rings are available in Bakelite, bronze, iron or other metals.

For additional information, write L. K. Pump Valve Company, 632 North Edgewood, Houston, *referring to* WORLD OIL *item* 42.

43—Rotary Swivel Joint

This item supplements Barco Manufacturing Company data as shown on page 637 of Composite Catalog, 17th Edition.

A new rotary swivel pipe joint for swivel and slow revolving applications eliminates wedge action of the ball against the gasket, thus reducing turning torque. The ball is held in place by a Belleville spring.



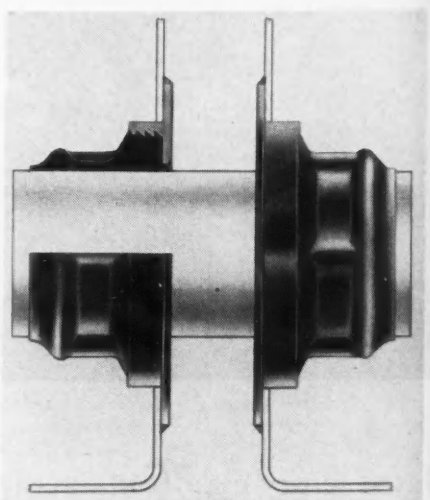
A small amount of side flexibility reduces the possibility of wear or breakage from side strain. Extra heavy models are available for extreme pressures and vacuums. Continuous rotation up to 30 revolutions per minute are possible. The joint will handle almost all fluids and gases, including corrosive acids and alkalis. It is available in 90-degree angle and straight designs in ⅜ to 1-inch sizes.

For additional information, write Barco Manufacturing Company, Department 135, 1801 West Winnemac, Chicago 40, *referring to* WORLD OIL *item* 43.

44—Mud Pit Flange

This item supplements Owen Tool Company data as shown on pages 3921-3928 of Composite Catalog, 17th Edition.

Designed for use on steel mud pits, a new mud pit flange permits a piece of plain end pipe to be used as the mud line between tanks. Providing a flexible connection, the flanges eliminate the necessity for unions and couplings and permit setting the tanks at any convenient distance apart and as much as 15 degrees out of alignment.

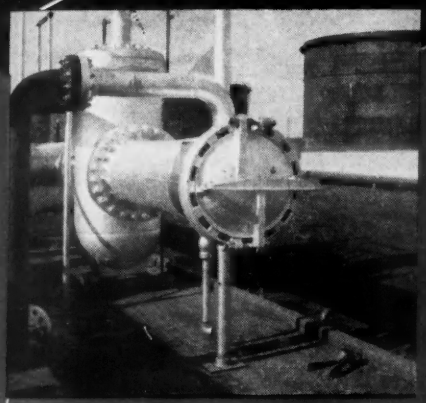


The flange is made in two pieces. A steel face plate, with female threaded neck, welds to the outside of the tank. A rubber sealing sleeve, self-sealing against water, mud or oil, makes up into the threads in the steel neck.

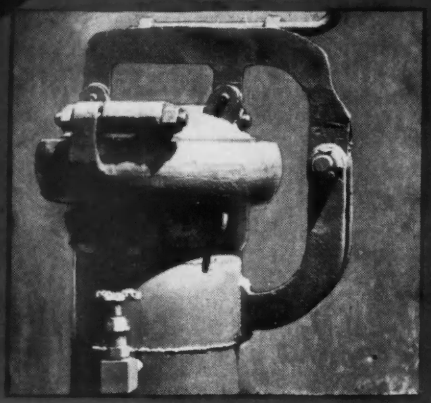
The flanges can be installed on any type of steel mud pits and are available in sizes for any pipe used for the connecting mud line.

For additional information, write Owen Tool Company, 4718 West 18th Street, Houston, *referring to* WORLD OIL *item* 44.

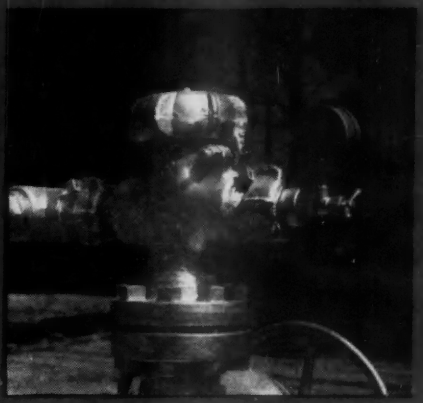
UNIBOLT PROVIDES A BETTER WAY TO DO THIS JOB!



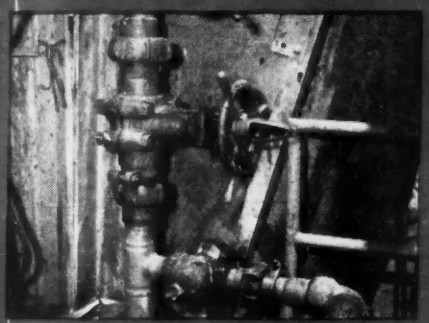
28-inch Hinged UNIBOLT Scraper Trap



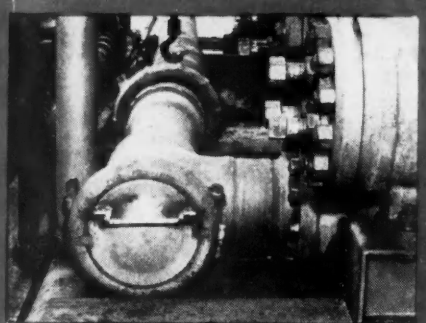
Hinged UNIBOLT Gas Pipeline Blow-Down



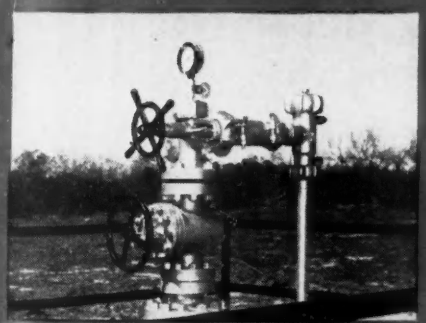
UNIBOLT Christmas Tree Cross with Blanking Plugs Tapped for Pressure Gauge



Mud Line Valves Equipped with UNIBOLT Couplings



UNIBOLT Slush Pump Strainer



UNIBOLT Flow Manifold

On any pipe connection . . . in any oil industry service . . . where flanged unions or closures are now employed, *UNIBOLT provides a better way to do the job.*

UNIBOLT provides a safer, stronger, joint because the unique UNIBOLT design places more metal in shear.

UNIBOLT provides a light-weight, less bulky unit which is economical, completely salvageable and interchangeable.

UNIBOLT provides a more convenient connection or closure because of its time-saving design, and blanking plugs which are available with a hinge to facilitate opening and closing.

UNIBOLT couplings are easily installed in hard-to-get-to places.

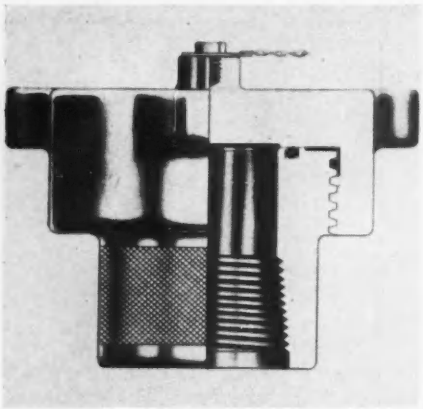
A few typical applications of UNIBOLT Couplings are presented herewith. See your Composite Catalog for complete mechanical details and other recommended UNIBOLT services.

THORNHILL-CRAVER CO.

HOUSTON UNIBOLT THE ONE BOLT COUPLING TEXAS

OTHER NEW AND IMPROVED EQUIPMENT

45—Blanking Plug Union



Utilizing an oil-resistant O-ring seal, a new blanking plug union consists of two parts; a threaded sub end containing the O-ring, for attaching to the line; and the blanking plug, which is available blank or tapped for drain cock. It is designed for use on pipe line scraper traps, jumper assemblies and manifolds.

The O-ring seals against all pressures or vacuum when the mating parts are snapped hand tight.

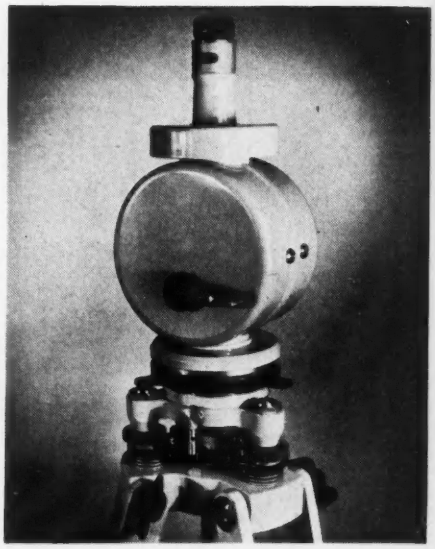
Sizes from one inch through 16 inches are available for working pressures as specified. In sizes up to eight inches, the blanking plug is connected to the sub end or line by a steel chain; sizes above eight inches have either steel chain or a hinged steel yoke.

For additional information, write Yale Machine Works, 4403 Yale Street, Houston, *referring to* WORLD OIL *item* 45.

46—Magnetometer

Patterned after the round-case Askania magnetometer, a new 10-volt vertical magnetometer is small and lightweight. The numbered scale has 120 divisions. Thermometer is on top of the instrument with the levels, for simplified observation.

By using a dovetail slide, cam and connecting rod arrangement, and turning the self-locking, releasing handle 180 degrees, the Askania-type system with quartz knife edge is lowered on the quartz bearings. A window in the side



of the instrument facilitates adjustments to the bearings and system.

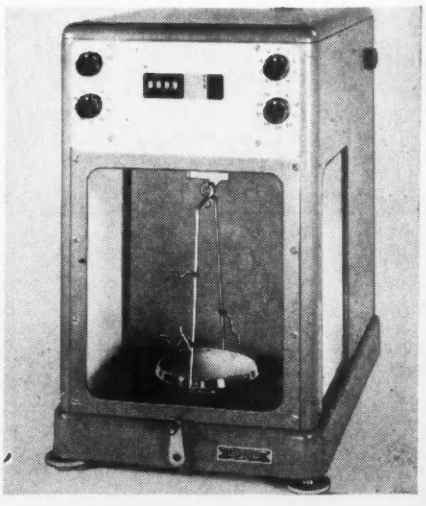
For additional information, write I. A. Robertson Instrument Company, 5022 Ennis Street, Houston 4, *referring to* WORLD OIL *item* 46.

47—Balance

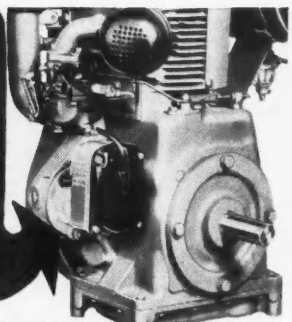
A new direct-reading instrument, the "Gram-atic" balance, weighs petroleum fraction samples to 1/20 of a milligram. The balance has only one pan, and the weight reads directly on a scale. All required weights are built-in and manipulated by turning four knobs. The sample to be weighed can range from seven ounces to 0.0001 gram.

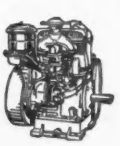
Knife edges and planes of the balance are sapphire, pan is gold plated, and entire case is aluminum with baked lacquer finish.

For additional information, write Fisher Scientific Company, 717 Forbes Street, Pittsburgh 19, *referring to* WORLD OIL *item* 47.



Why WISCONSIN HEAVY-DUTY Air-Cooled ENGINES Have a Rotary-Type OUTSIDE MAGNETO





Perhaps you have never given much thought to the placing of a Magneto on an engine, nor whether it's of the "flywheel" or "Rotary" type. It's an important point because the magneto is really the heart of the engine. When it fails, your power fails.

Wisconsin engineers have found through long experience and experimentation that the best place to put the magneto, not only for convenient accessibility but for better ignition performance over an extended period of time is on the OUTSIDE . . . with an independent, direct drive from the engine to the Magneto. The Rotary Type high tension magnetos used by Wisconsin Air-Cooled Engines provide the greatest protection against ignition troubles because the Magneto itself is a complete, independent operating unit that doesn't rely on an unrelated part of the engine for its successful operation. It's tightly sealed against dust and moisture, of course, so it isn't affected by wet weather or snow and there is no chance of it getting "fouled up". And it's equipped with an *Impulse Coupling* that provides a quick, hot spark for easy starting in any weather, in any climate, a feature that can't be incorporated in flywheel-type magneto.

Yes, the MAGNETO is important . . . both as to *type* and *placing* on the engine. It's the *right kind* and in the *right place* on Wisconsin Heavy-Duty Air-Cooled Engines. Specify "Wisconsin" for your 3 to 30 hp. power needs. . . . Descriptive literature on request.

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World's Largest Builders of Heavy-Duty Air-Cooled Engines

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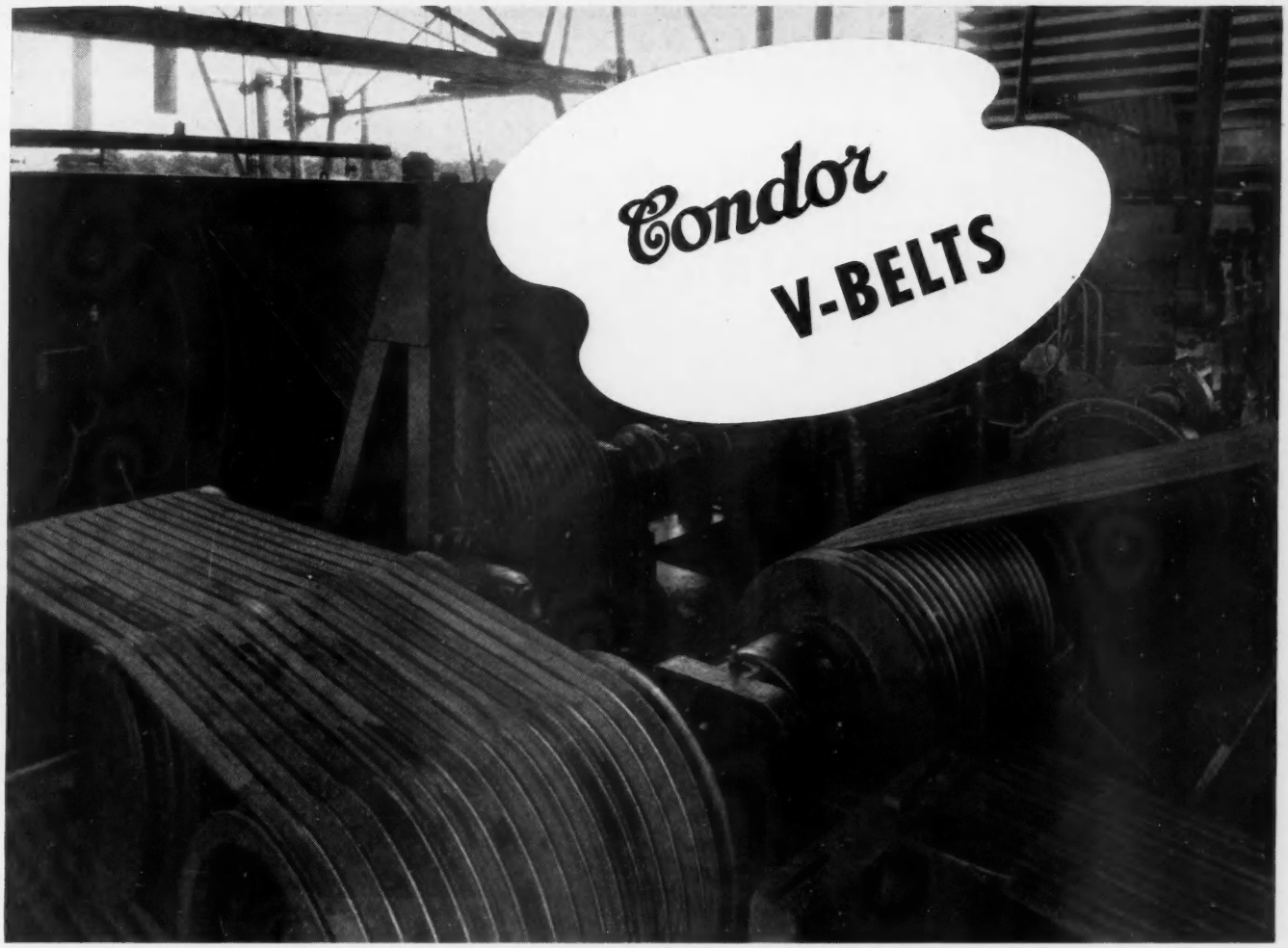
Oil field distributors for Wisconsin Engines and all types of utility units.



Cut Costs on Diesel Rigs

Manhattan's method of pre-stretching the strength members of Condor V-Belts builds balanced V-belt teams that pull together to cut your belting costs. Every belt pulls its share so no belt takes destructive strains. There is no slippage due to excessive stretch.

Strength members impregnated and covered with Flexlastics insure uniform, cool-running power delivery. Plenty of cushion assures long wear. Rugged side wall construction gives positive traction grip for maximum power. Heavy duty covers are weather-proof, yet flexible and smooth-running.

You can also profit from the advantage of Manhattan V-belts in Oil-Proof and Non-Spark constructions.

Whatever your requirements, your rigs will run smoother if you equip every part with Manhattan—Rotary Hose, API Flat Transmission Belts, Condor V-Belts, etc. Try Manhattan and compare for quality.

("Flexlastics" is exclusive with Manhattan)

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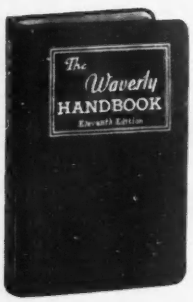

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OTHER NEW EQUIPMENT

48—Trenching Machine

The Everett Trencher is mounted on a Ferguson tractor driven from the power take-off and raised and lowered by the tractor's hydraulic system. The machine has adjustable clearance teeth and digs from 12 to 18 inches in width. It is possible with the new trencher to dig an additional width trench by extending the wheel width of the tractor. The trencher will cut any depth to 42 inches, and it travels from 1½ to five feet a minute, depending upon the depth and width of cut and type of soil.

The machine has a special transmission for necessary speed reduction. It can travel over curbs and up inclines and can be moved from job to job under the tractor's own power or be transported by trailer.

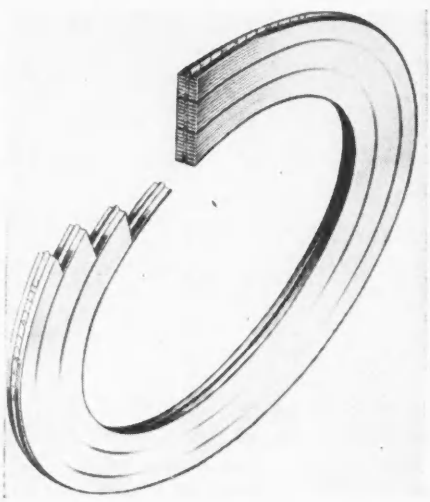
For additional information write The Tractor Sales Corporation, 1419 Santa Fe Avenue, Los Angeles, *referring to* World Oil *item* 48.

49—Metal Gasket

A flexible all-metal gasket has been developed for high pressure and high temperature applications. The gasket does not take a permanent "set" and remains resilient throughout variations of pressure and tempearture.

The flexible gasket is adaptable to applications where high temperature and permeability of confined materials limit the use of soft fillers.

For additional information, write Flexitallic Gasket Company, Camden, N. J., *referring to* World Oil *item* 49.



50—Coring Service

"Spiral-Set" diamond bits and diamond core barrels are used in a new diamond coring service of Core Laboratories, Inc. The bits are made with two standard cutting face patterns: the general purpose pattern for coring in medium abrasive formations, and the hard pattern for coring in hard or fractured formations.

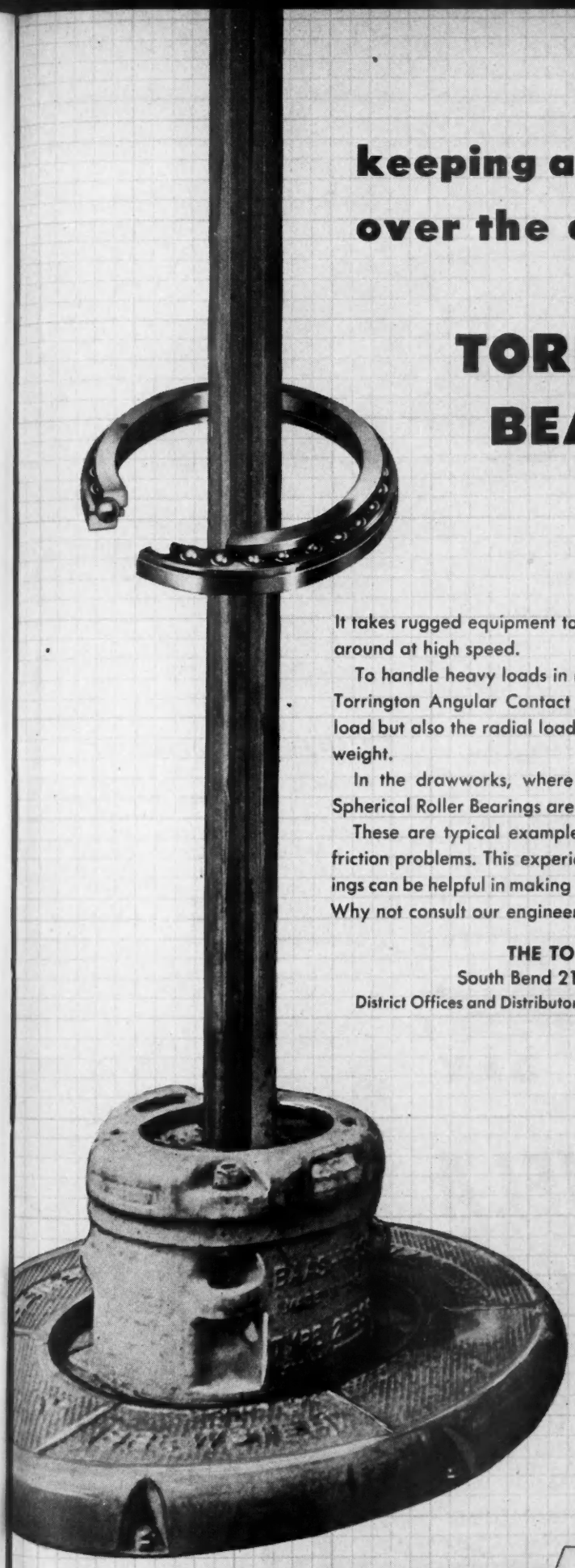
Diamonds in both bits are set in a

diagrammed mold consisting of a series of recesses formed in spirals.

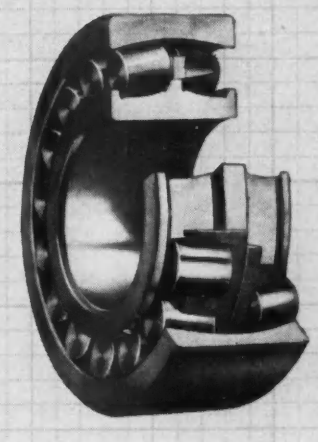
Not more than half of the leading edge of each diamond is presented to the formation being cored. Cuttings are thrown toward the outer periphery of the bit face, and the fluid flow washes the particles away through radial and spiral channels.

A signalling mechanism in the core barrel warns the driller when core is lodged in the inner barrel. A bearing housing containing a floating piston arrangement maintains consistent equalization of pressure to prevent fluid from contaminating the bearing lubricant.

For additional information, write Core Laboratories, Inc., P. O. Box 5810, Dallas, *referring to* World Oil *item* 50.



keeping a whip hand over the drill string...



TORRINGTON BEARINGS

It takes rugged equipment to control a mile and a half of drill pipe lashing around at high speed.

To handle heavy loads in rotary tables, The Brewster Company specifies Torrington Angular Contact Ball Bearings. They carry not only the thrust load but also the radial load imposed by the driving gear and unbalanced weight.

In the drawworks, where shafts are subject to deflection, Torrington Spherical Roller Bearings are used to insure smooth operation and long life.

These are typical examples of Torrington's ability to solve all kinds of friction problems. This experience with all major types of anti-friction bearings can be helpful in making your equipment give more dependable service. Why not consult our engineers on your next bearing application?

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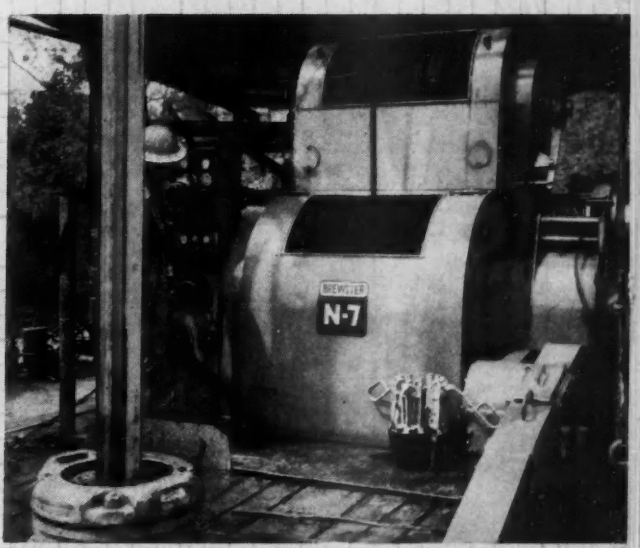

TORRINGTON *SPHERICAL ROLLER* **BEARINGS**

SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • NEEDLE • BALL • NEEDLE ROLLERS

51—Drilling Equipment

Latest catalogs of the Chiksan Company and Well Equipment Manufacturing Corporation have been combined. Complete specifications, including overall dimensions and color codes of Chiksan's ball-bearing swivel joints are contained in Catalog No. 50. Basic types of ball-bearing swivel joints are described and illustrated. An up-to-date price list is shown. Illustrated also are cementing and circulating hose, circulating head, loading racks, mud mixing gun, rotary hose, etc.

Weco's catalog lists such equipment as their new "Junior" all-steel union, as well as other unions. Also described are the Weco thread compounds, drop-side snatch blocks, gauge protectors, fusible plugs, burners, and Okadee valves.

For a copy of this catalog, write Chiksan Company, P. O. Box 158, Brea, Calif., *referring to* WORLD OIL *item* 51.

52—Oil Field Equipment

"Oil Field Equipment" is the title of American Iron and Machine Works Company's new 1949-50 catalog of its products. This new 50-page catalog describes and illustrates oil field equipment manufactured by the company, and in many instances the manufacturing facilities are shown. Included are price lists and equipment rental rates. The section on the "Straight Grip" tool joint is illustrated with cut-away photographs. Illustrations and instructions show how to change tool joints in the field. Complete engineering data are presented on the Straight Grip tool joints.

For a copy of this catalog, write American Iron and Machine Works Company, P. O. Box 1177, Oklahoma City, *referring to* WORLD OIL *item* 52.

53—Diamond Core Bits

A four-page, two-color folder contains descriptions of techniques used in the manufacture of Spiral-Set diamond core bits. A comprehensive cutaway drawing illustrates operating features of the diamond core barrel.

For a copy of this folder write Core Laboratories, Inc., P. O. Box 5810, Dallas, *referring to* WORLD OIL *item* 53.

54—Water Knockouts

Removing relatively large volumes of water from oil is the subject of a new catalog on Free Water Knockouts. Phantom diagrams in color illustrate the water separating principle of the BS&B free water knockouts. Capacities and specifications are included with installation photographs.

For a copy of this catalog, write Black, Sivalls & Bryson, Inc., 720 Delaware, Kansas City, Mo., *referring to* WORLD OIL *item* 54.

55—Packaged Rig Power

A four-page two-color brochure titled, "Packaged Power for Your Rig" describes prefabricated and unitized equipment for supplying electricity, compressed air and water for the drilling rig.

For a copy of this brochure write Louisiana Machinery Company, Inc., Shreveport, *referring to* WORLD OIL *item* 55.

56—Well Logging

A brief discussion of methods and equipment used in Hydrocarbon Profile Well Logging is contained in a new booklet. In addition to explaining what this type logging will accomplish in drilling wells, six pages of this 14-page booklet contain engineering graphs used in drilling calculations.

For a copy of this booklet, write The Hycalog Company, 517 First National Bank Building, Shreveport, *referring to* WORLD OIL *item* 56.

57—Pumps, Compressors

Catalog GC-9 describes the Jaeger equipment line, including "Sure Prime" pumps, the "Bantam," and other models. Specifications of each type are presented with a set of performance curves for electric pumps and high and low head Caisson pumps. The line of air compressors is shown with specifications for each model and type. Other equipment described includes concrete mixers, hoists, and paving machinery.

For a copy of this catalog, write The Jaeger Machine Company, 550 West Spring Street, Columbus 16, O., *referring to* WORLD OIL *item* 57.

58—Indirect Heaters

Selection of the most efficient indirect heater for oil field applications is discussed in BS&B Catalog 54, of which Part 1, Section 3, treats of the problems and latest equipment in heating. The five sections comprising the 82-page catalog are: 1. Description of the indirect heaters; 2. Specifications of the various sizes indirect heaters; 3. Procedure for solving gas heating problems; 4. Procedure for solving oil heating problems; and 5. A supply of data and calculation sheets for both gas and oil heating problems.

For a copy of this catalog, write Black, Sivalls & Bryson, Inc., 720 Delaware, Kansas City, Mo., *referring to* WORLD OIL *item* 58.

59—Pumping Units

Detailed engineering specifications and description of the Alten A-33-6 pumping unit are contained in a pamphlet which also lists important features of the gear reducer.

For a copy of this pamphlet, write Altens Foundry & Machine Works, Inc., Lancaster, O., *referring to* WORLD OIL *item* 59.

EACH WAY-EVERY DAY

DAILY Flights to

VENEZUELA and JAMAICA!

Chicago & Southern Air Lines' fleet of 4-motored Douglas Skymasters now offers seven-days-a-week service through the Houston and New Orleans gateways to Caracas, Kingston, and Havana. Flights each way every day provide one-plane service from the Great Lakes to the Venezuelan oil capital. Ask your travel agent or nearest C&S ticket office.

CHICAGO & SOUTHERN AIR LINES

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C★S

You ordered this finer Gauge!

You asked for pressure gauges that would stay accurate under the unequalled punishment of oil country service.

Our answer was the Marsh Mastergauge series—gauges with the rugged bourdon tube and the heavy-duty precision movement built to withstand the extremes of pressure, temperature, pulsation, vibration.

Today thousands of Marsh Gauges throughout the oil industry prove that we found the *right* answer. You ordered this finer gauge. It is ready for you at your local supply store.

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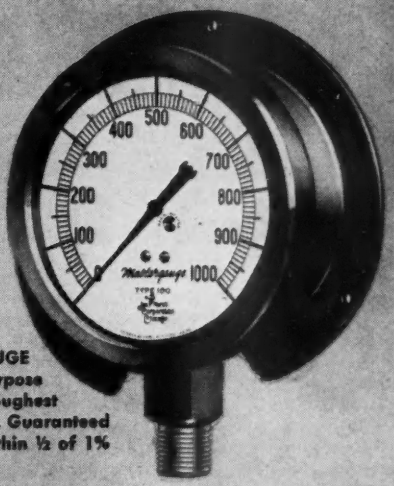
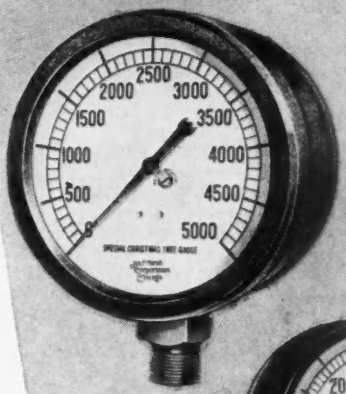
This Oil Industry Bulletin is yours for the asking

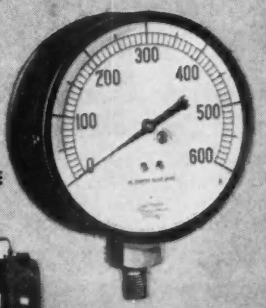
The Marsh branch plant at Houston offers shipment from stock and facilities for repairing all makes of gauges.



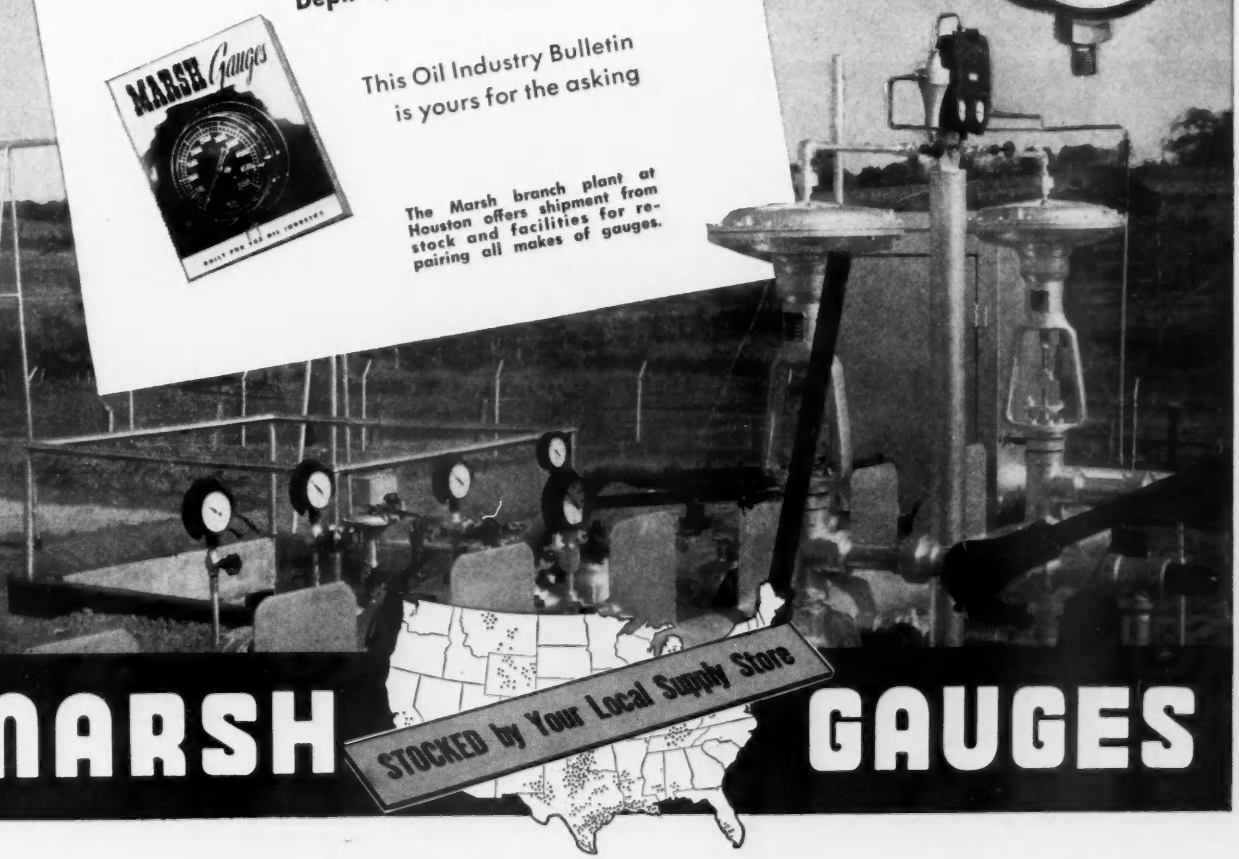
MASTERGAUGE —the all-purpose gauge for toughest applications. Guaranteed accurate within ½ of 1% of reading.



CHRISTMAS TREE GAUGE—a gauge that incorporates ruggedness and accuracy beyond all others.



OIL COUNTRY BOILER GAUGE



MARSH GAUGES

STOCKED by Your Local Supply Store

Associations

Oklahoma API Chapters Name Officers and Committeemen

Sam F. Shakly, Anderson-Prichard Oil Corporation, was elected chairman of the Oklahoma City Chapter, API, succeeding W. M. Edinger, who becomes chairman of the advisory board. G. E. Saunders, Sohio Petroleum Company, was elected vice chairman. Group vice chairmen are W. W. Heavner, Continental Supply Company, membership; Kenneth E. Fink, Shell Oil Company, and B. Burke, Sohio, programs; J. A. Kornfeld, Sohio, publicity; C. L. Kirkman, Lane-Wells Company, secretary-treasurer.

J. W. Hudson, Republic Natural Gas Company, was elected chairman of the Golden Trend Chapter, API, succeeding Ned Biffle, drilling contractor. H. W. Holliday, Sohio, is secretary-treasurer. Group vice chairmen are Sid Bullard, programs; M. L. Morris, Sohio, membership; Sam Harris, Kerr-McGee Oil Industries, Inc., publicity; George Battles, Halliburton Oil Well Cementing Company, meeting places.

SPEAKERS AND PRESIDING OFFICERS are pictured at the annual joint meeting of the Texas Sections of the AIME, held at Texas A. & M. College. Eleven papers on drilling and producing operations were presented at the two-day meeting. Left to right are (standing) Bill R. Weaver, Tide Water Associated Oil Company, Midland; Robert E. Bush, Lane-Wells Company; Bruce Barkis, B & W, Inc., Houston; A. B. Stevens, Texas A. & M. College; Robert Todd, Core Laboratories, Inc., Dallas; and R. L. Whiting, Texas A. & M. College; (seated) George C. Howard, Stanolind Oil & Gas Company; George H. Fancher, University of Texas; and Edward Kelly, Dowell Incorporated, Houston.

Penn Grade Appoints Wheeler Pacific Coast Representative

Charles R. Wheeler, Glendale, Calif., has been appointed Pacific Coast field service representative for the Pennsylvania Grade Crude Oil Association. He succeeds E. H. Fallin, who has resigned to join the National Petroleum Association in Washington, D. C.

Wheeler, who for several years has been with the Veterans Administration, was previously Penn Grade representative in the Midwest, with headquarters in Chicago.

Exploration Geophysicists Announce 1950-51 Nominees

Nominees for executive offices of the Society of Exploration Geophysicists for 1950-1951 are, for president, George E. Wagoner, The Carter Oil Company, Shreveport, and Maurice Ewing, Columbia University, New York; vice president, Dayton H. Clewell, Magnolia Petroleum Company, Dallas, and Sigmund Hammer, Gulf Research and Development Company, Pittsburgh; secretary-treasurer, Francis F. Campbell, Amerada Petroleum Corporation, Tulsa, and William H. Courtier, Phillips Petroleum Company, Bartlesville.

Results of a mail ballot will be announced in April.

Herron Heads Panhandle Group

The Panhandle Geological Society, Amarillo, Texas, has elected Robert F. Herron, Oil Development Company, president. Other officers are Robert B. Totten, Sun Oil Company, vice president; Raymond A. Fickel, Sinclair Oil & Gas Company, treasurer; and Miss Louise Jordan, Sun Oil Company, secretary.

Westmoreland Is Chosen

Earl Westmoreland, Seaboard Oil Company, has been elected president of the Ardmore Geological Society, succeeding I. Curtis Hicks, Phillips Petroleum Company. Harold Weichbrodt and Frank Millard are vice president and secretary-treasurer, respectively.

Gotkool
WATER CANS
& COOLERS
GOTT Water Cans are the practical way to keep drinking water cool for long periods, protected from impurities and always handy to the job. Snug fitting large removable top, strongly built to withstand rough usage. GOTT Water Coolers have extra large covers and a handy non-leaking push button faucet. Your Supply Store has them, get one today! . . . . . .
GOTT
WATER CAN
GOTKOOL WATER CAN
Made in 1½, 2, 3, 5, 10, 15 and 20 gallon sizes. (Push-Button Faucet at slight additional cost.)
GOTT
GOTKOOL WATER COOLER
Made in 2, 3, 5, 8, 10, 15 and 20 gallon sizes with Push-Button Faucet.
H. P. GOTT MFG. CO.
WINFIELD, KANSAS
KEEP PURE DRINKING WATER ALWAYS HANDY

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FORMALDEHYDE

for corrosion control

You can protect your casings, rods, and all exposed metal parts for only a few cents a day. You can

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Thompson-Hayward Formaldehyde gives dependable protection from hydrogen sulphide corrosion and corrosive mine and well waters.

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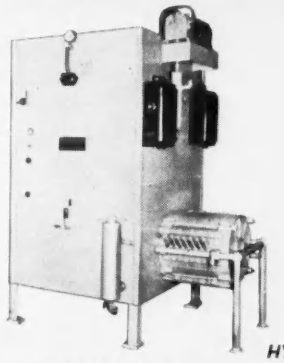
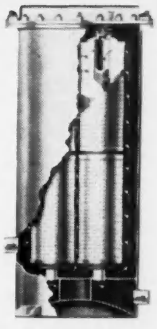
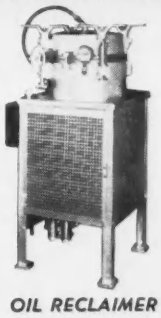
PURIFIERS · FILTERS · RECLAIMERS · CONDITIONERS



AIRLINE OIL PURIFIER



HYFLOW OIL FILTERS



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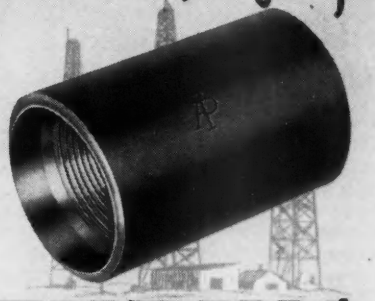


OIL WELL TUBING COUPLINGS

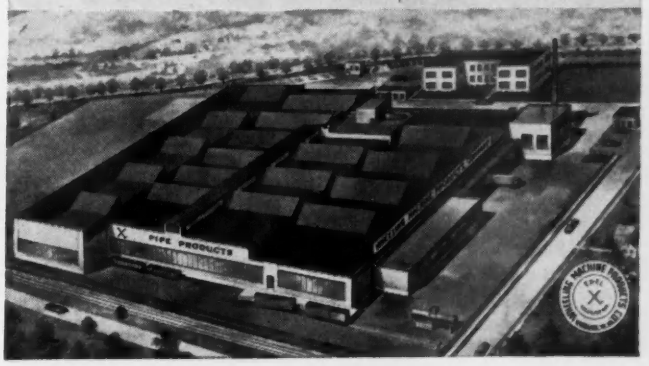
You can always be sure of trouble-free joints when you specify "X-L" Quality Oil Well Tubing Couplings. They're made to assure perfect alignment, tighter joints and to protect vanishing threads. "X-L" Couplings are available in Plain or External Upset for standard tubing. Manufactured from steel; tested by Comparator to assure strict adherence to A.P.I. standards. "X-L" Couplings are used by every pipe mill in the United States and Canada.

Save Time and Error!
Use Our Catalog Description
When Ordering Couplings!

WHEELING MACHINE PRODUCTS COMPANY

WHEELING, WEST VIRGINIA

World's Largest Independent Producer of Pipe Couplings



Western Oil Group Selects Officers and Committeemen

Reese H. Taylor, president of the Union Oil Company of California, has been elected to his second term as president of the Western Oil and Gas Association. Also re-elected by the board of directors are William Reinhardt, vice president of Union Pacific Railroad Company, first vice president; William F. Humphrey, president of Tide Water Associated Oil Company, second vice president; L. K. Whittier, vice president of Belridge Oil Company, treasurer; and D. S. Kilgour, secretary.

The position of executive secretary was abolished and John M. Peirce, who had held that post since June, 1948, was named to the new position of vice president and general manager.

Three new directors elected are C. M. Cotton, vice president, Jergins Oil Company, Long Beach; John T. Pigott, president, Kern County Land Company, San Francisco; and L. W. Saunders, president Independent Exploration Company, Bakersfield.

Twenty-nine incumbent members of the board were re-elected.

Robert L. Minckler, president of General Petroleum Corporation, was named to head a special eight-man committee on Percentage Depletion of the Western Oil and Gas Association. The committee will plan and direct the association's approach to the problem, which is expected to be the subject of a Congressional inquiry.

Other committee members are C. A. Johnson, president, Holly Development Company, vice chairman; L. L. Aubert, president, Bankline Oil Company; William F. Humphrey, president, Tide Water Associated Oil Company; Charles S. Jones, president, Richfield Oil Corporation; T. S. Petersen, president, Standard Oil Company of California; C. P. Watson, vice president, Seaboard Oil Company of Delaware; and W. C. Whaley, vice president, Barnsdall Oil Company.

For WIRE LINE CORING

Be Sure IT'S A KING *Be Safe*

USE

KING 4C CIRCULATING HEAD AND 4AR WIRE LINE STRIPPER

The King 4C Circulating Head and 4AR Wire Line Stripper are companion tools and best results are obtained when they are used together. When used together, they are so compact as a unit, that pipe can be raised and lowered with short bail elevators.

KING 4C CIRCULATING HEAD

The King 4C Circulating Head has a 3" clear opening through it. The spindle can be furnished for any commonly used tool joint pin. The top of the circulating head has a 4" female pipe thread, and the gooseneck a 3" female pipe thread. Bearings are sealed in the housing with a grease nipple provided.

KING 4AR WIRE LINE STRIPPER

The King 4AR Wire Line Stripper is an automatic release type, having a positive latch and a sure release. Bronze rollers guide the line and are equipped with grease nipples for lubrication. Rubber strippers are inserted from the sides and can be renewed while the line is in the hole. This tool is non-sparking which lessens the fire hazard.

For Swabbing Use KING Type 3AR Wire Line Stripper

See Composite Catalog for other King Oil Tools. All prices F.O.B. Houston, Texas, and subject to change without notice.

Complete details upon request. Order through Your Supply Store.

Export: **R. S. STOKVIS & SON, Inc.**
17 Battery Place, New York 4, N. Y.

KING OIL TOOLS

210 TERMINAL STREET PHONE WO-8013

HOUSTON 20, TEXAS

Western Canada Oil Men Name Humphreys Group Secretary

Griffith L. Humphreys

The Western Canada Petroleum Association has appointed Griffith L. Humphreys as secretary to succeed the late E. W. Kolb. Humphreys was formerly associated with Imperial Oil, Ltd. In January, 1949, he joined Harry Forrester Limited, Calgary, Alberta, in the Accounting department.

San Francisco Geologist Is Elected President of AIME

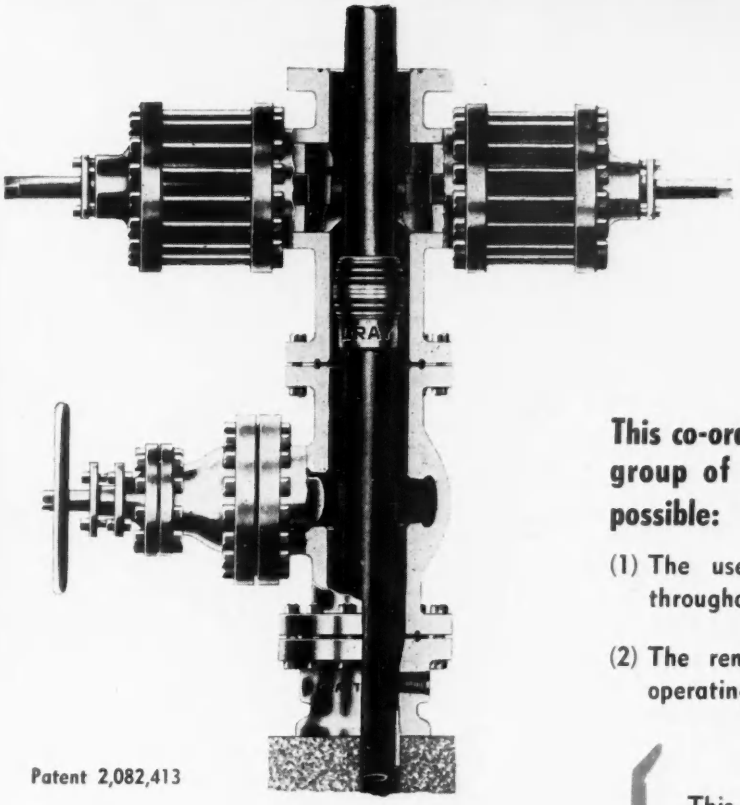
Donald H. McLaughlin, geologist and president of the Homestake Mining Company, San Francisco, has been elected president of the American Institute of Mining and Metallurgical Engineers for 1950.

Andrew Fletcher, president, St. Joseph Lead Company, New York City; and Robert W. Thomas, general manager, Nevada Consolidated Copper Corporation, Ray, Ariz., were named vice presidents. New directors are Harold Decker, president, Houston Oil Company of Texas, Houston; Francis B. Foley, superintendent of research, The Midvale Company, Philadelphia; E. C. Meagher, treasurer, Texas Gulf Sulphur Company, New York; Gail F. Moulton, geologist, Department of Petroleum Economics, The Chase National Bank, New York; and Howard I. Young, president, American Zinc, Lead & Smelting Company, St. Louis.

IOCC Plans Meeting at Biloxi

"Oil and Gas Conservation and the Public Interest" will be the theme of the Interstate Oil Compact Commission at Biloxi, Miss., May 4, 5 and 6. Governor Roy J. Turner of Oklahoma, chairman of the Commission, will preside.

GRAY SYSTEMS OF WELL CONTROL INCLUDE THESE DEVELOPMENTS



Patent 2,082,413

THE WHOLE IS THE SUM OF ITS PARTS

This "ASA Series" system of well control combines:

(1) The boll weevil system of suspending and sealing the outside of an inner string, together with provision for controlling flow through the inside; and

(2) The use of control equipment of a size related to and balanced with a given size casing and other equipment.

This co-ordination of an otherwise heterogeneous group of unrelated parts and fittings makes possible:

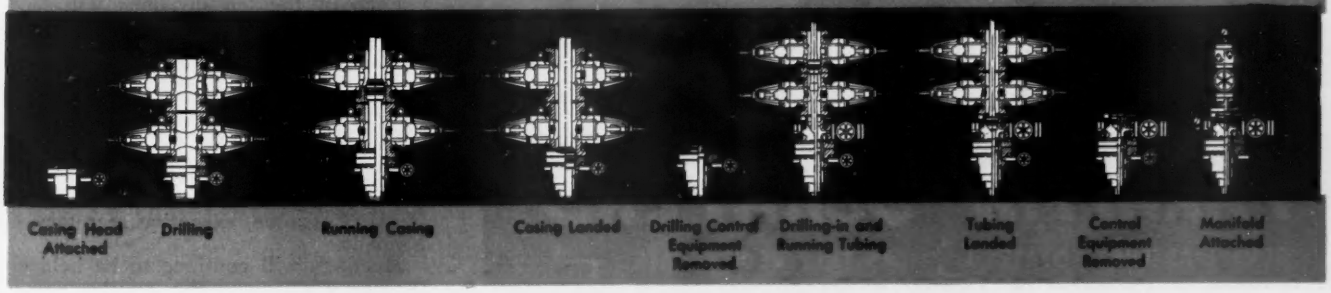
(1) The use of a wide choice of control equipment throughout its full operating function; and

(2) The removal of said equipment when and as said operating function is completed.

This method provides for the use of parts and fittings as a co-ordinated "whole." It avoids the inherent weaknesses which exist and accompany failure to study the whole of a problem in addition to the parts thereof.

GRAY TOOL COMPANY
HOUSTON

Rocky Mountain Representative: CARL MOULDEN, P. O. Box 1890, Casper, Wyoming



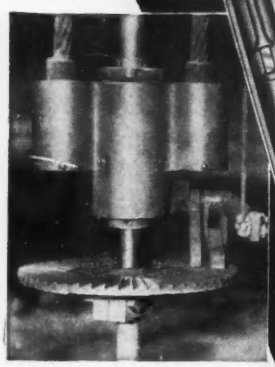
ACCIDENT PREVENTION among oil field drilling crews was discussed at Dallas by the Safety Committee of the AAODC. Seated, left to right, are Roger Dalgleish, Big Chief Drilling Company; J. S. Bell, W. H. Black Drilling Company; Harold L. Rowley, Big Chief Drilling, Mississippi committee chairman; J. Doyle Settle, AAODC, Dallas, committee secretary; John S. Jackson, Danciger Oil & Refining Company, committee vice chairman; and Sam King, Kerr-McGee Oil Industries, Inc. Standing, left to right, Claude Pipes, Texas Employers Insurance Association; H. B. Zigler, Halliburton Oil Well Cementing Company; Roy Dishman, Hunt Oil Company; Fred Claiborne, Stanolind Oil and Gas Company; C. W. Yancey, Rowan Drilling Company, Inc.; G. W. Hutcheson, George P. Livermore, Inc., C. E. Louden, Employer's Mutual Insurance Company; J. C. Anderson, Loffland Brothers Company; W. W. Duncan, Loffland Brothers; and F. C. Cooper, Sohio Oil Company.

WHAT ARE YOU PAYING FOR PARAFFIN REMOVAL?

TOO MUCH — If your pumping wells are not equipped with HUBER SCRAPERS

Many major companies report Huber Scrapers have completely eliminated paraffin removal costs or reduced them to only a fraction of a cent per barrel of oil produced. Huber Scrapers, shrink-fitted to new or used sucker rods, scrape the paraffin from the tubing wall as the string rotates and reciprocates. Rods are rotated by the special Huber Rotating Rod Hanger.

Reduce or eliminate your paraffin removal costs with Huber Scrapers. Write for latest bulletin.



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Tulsa Corrosion Short Course Will Be Held February 20-23

The Tulsa Section of NACE will sponsor a four-day school in corrosion control for pipe line superintendents, foremen, engineers and inspectors, at Tulsa February 20 through 23. The short course will cover pipe coatings, anode and rectifier installations, and pipe corrosion testing. Two days will be devoted to field work at pipe line locations.

R. L. Bullock, Interstate Oil Pipe Line Company, heads the committee on planning and direction, and is assisted by F. E. Pyeatt, Mid-Continent Pipe Line Company; J. C. Sterling, Stanolind Pipe Line Company; and I. B. Tietze, Phillips Pipe Line Company.

Eisenhower Will Speak at AIME Meeting in New York

General Dwight D. Eisenhower, president of Columbia University, will speak at a luncheon Monday, February 13, opening the AIME Annual Meeting in New York.

Each of the ten divisions will have one or more sessions.

Dallas Nomads Change Name

Name of the Dallas Chapter of Nomads has been officially changed to Dallas-Fort Worth Chapter of Nomads. The new charter will be presented at the February meeting in Fort Worth by H. M. Cosgrove, executive secretary of Nomads.

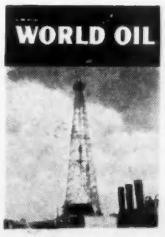
Meetings will continue to be held on the first Monday of the month.

Who Else

besides you is reading WORLD OIL this month?

In The Texas Company, 643 paid subscribers plus many oil men who read pass-along copies. Of these, 477 are in the U. S. A., Canada, Venezuela and Colombia, of which 47 are executives, the remainder engineers, superintendents, foremen, geologists, purchasing agents and others including field workers. Affiliated companies account for 166 others.

The Texas Company, one of the world's greatest, owns assets of over half a billion dollars. In 1948 it spent $235,000,000 on producing and other property developments, drilled 842 wells, produced 118,375,473 gross barrels of oil.



THE PETROLEUM PUBLICATION SPECIALIZED FOR EXPLORATION-DRILLING-PRODUCTION-PIPELINE OPERATIONS AND MANAGEMENT

Men in the Industry NEWS

Warren L. Baker, editor of WORLD OIL, has been appointed editorial director of The Gulf Publishing Company, publisher of WORLD OIL, *Petroleum Refiner, Composite Catalog,* and *Refinery Catalog.*

Warren L. Baker

Baker joined *The Oil Weekly,* predecessor of WORLD OIL, while completing his education at Tulsa. In 1925 he joined Ira Rinehart Oil News Company, Tulsa, and served as managing editor in 1927 and 1928. Returning to *The Oil Weekly* in 1928, he became district editor for Oklahoma and Kansas. He served as associate editor of *The Petroleum Engineer* from March, 1930, until February, 1934, when he became associate editor of *The Oil Weekly.* He was made etditor in 1935.

In 1939 Baker was elected a director of Gulf Publishing, and in 1943 was elected secretary.

He is a member of the API, and was Texas state chairman of its Petroleum Industry Public Relations Program from 1947 until 1949. He is also a member of AIME, National Oil Scouts and Landmen's Association, Houston Geological Association, and is president of the Association of Petroleum Writers.

•

George M. Clement, who has been with The Texas Company 16 years, has been promoted to departmental geologist, Producing department, Houston. He was advanced from assistant departmental geologist.

Clement was graduated from the University of South Dakota with a B.A. degree in 1928. He worked two years for Shell Oil Company as an assistant geologist, and then was employed as a graduate assistant and research assistant at the University of Iowa while completing study for the Ph.D. degree in geology. In 1933 he joined The Texas Company at Shreveport.

•

J. L. Martin, vice president and director of pipe lines for General Petroleum Corporation, has retired, and has been succeeded by **George H. Supple,** formerly manager of the Pipe Line department.

A pipe-liner for 45 years, Martin joined General Petroleum in 1913 as assistant superintendent of the Pipe Line department. He was made vice president and director of pipe lines in 1948.

Supple has had 25 years with the company. He entered the Pipe Line department in 1935 as assistant to the manager, and was made manager in 1948.

Dean M. Fox is the new district superintendent for General Petroleum in the Rocky Mountain area, and will supervise both drilling and production in Wyoming, Montana and Colorado. He will continue to make his headquarters in Casper, Wyo.

L. F. Knox, chief safety engineer, has retired after 23 years with the company. Knox, a graduate of the University of Minnesota School of Mines, joined General Petroleum in 1926.

•

James Harvey Burch has been named production foreman of the Oklahoma City district for British-American Oil Producing Company. **Eathen Allen** has been named British-American field superintendent at Hoisington, Kansas.

•

Stanley G. Wissler, chief paleontologist, Pacific Coast area, Union Oil Company of California, is now chief geologist for the area in charge of geological exploration.

John R. Donnell

Charles H. Smith

John R. Donnell has been named treasurer of The Ohio Oil Company succeeding **Charles H. Smith,** retired. Donnell joined the company in 1936 as special representative in the Findlay, O., offices and has been assistant to the manager of production since 1944. He is a director and secretary of the Rock River Petroleum Company and a member of the API.

Fred E. Smith

Smith joined the company in 1906 and was made treasurer in 1946.

Fred E. Smith, general superintendent of the Production department for the past six years, has been appointed assistant manager of the department. He joined the company in 1914.

•

H. D. Collier has resigned as chairman of the board of directors of Standard Oil Company of California, but will continue as a director and chairman of the Finance Committee. **R. G. Follis,** vice chairman and formerly president, was elected by the board to succeed Collier as chairman. **T. S. Petersen** will continue as president.

WORKING DIRECTORS of The Standard Oil Company (Ohio) are pictured as the company observes its 80th birthday. From left to right are E. D. Wallace, vice president in charge of production; S. H. Elliott, vice president, transportation; A. A. Stambaugh, vice president, sales; C. T. Foster, president; W. T. Holliday, chairman of the board; E. B. McConnell, vice president, manufacturing; and W. A. McAfee, general counsel.

MEN IN THE INDUSTRY NEWS

F. R. Yost

J. G. Bartram

F. R. Yost, manager of the Producing department, Stanolind Oil and Gas Company, has been elected a member of Stanolind's board of directors.

C. T. Jones

Yost, who studied business administration at the University of Texas, joined Stanolind in 1935, and in 1943 was named head of the Industrial Relations department for the Texas - Louisiana Gulf Coast division at Houston. Later that year he became district production superintendent at Tallahassee, Fla., where he remained until his transfer to Tulsa as district production superintendent for Kansas. He was made drilling superintendent for the Producing department in 1945, operating superintendent in 1947, and manager of the Producing department on February 1, 1949.

J. G. Bartram, formerly manager of Stanolind's Exploration department, has been named consulting geologist, and has been succeeded by **Charles T. Jones.** Jones was manager of the Central division with offices in Oklahoma City and is succeeded in that post by **J. E. Swearingen,** formerly executive assistant to the vice president in charge of operations.

George B. Jenkinson has been made assistant to the manager of the Exploration department and is in charge of foreign exploration. **C. F. Schock,** who has been division exploration superintendent in Canada, has been made manager of the Canadian division.

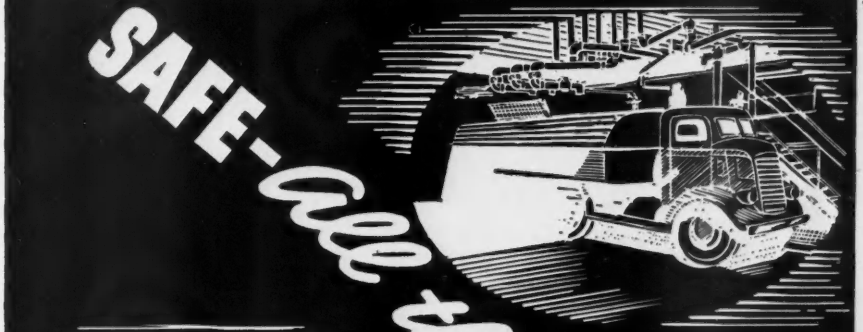
•

Don R. Gladney, superintendent of the Right-of-Way and Claims department, Magnolia Pipe Line Company, and a member of the board of directors, has retired after 36 years with the company. **William Pilley** succeeds Gladney as superintendent of Right-of-Way and Claims department.

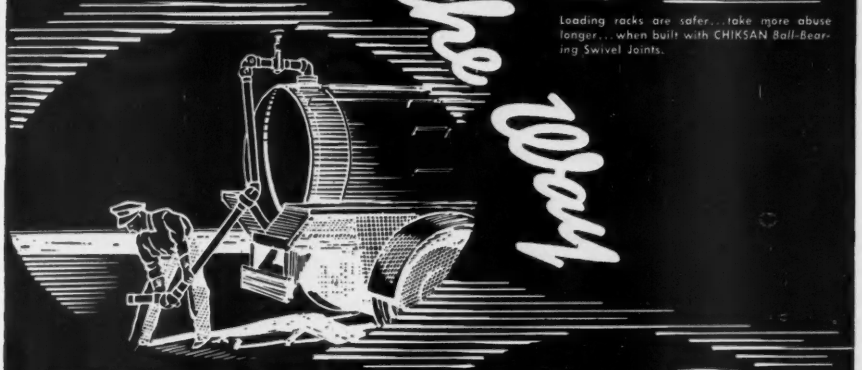
•

M. P. Appleby has resigned as a director and vice president-treasurer of Wilcox Oil Company, Tulsa, to become an independent operator and has been succeeded by **Carl L. Miller** as secretary-treasurer. **A. L. Chapman** was promoted to vice president and **Bert E. Lane** was made assistant secretary-treasurer.

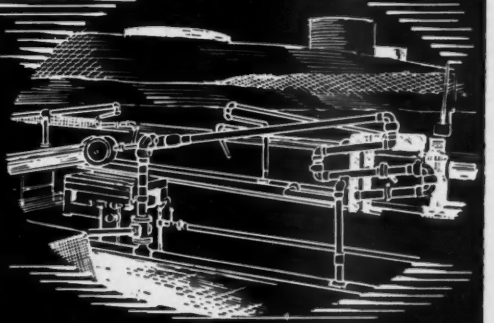
SAFE-all the way



Loading racks are safer...take more abuse longer...when built with CHIKSAN *Ball-Bearing* Swivel Joints.



For greater safety and longer life, use CHIKSAN *Ball-Bearing* Swivel Joints in loading and unloading lines handling most types of chemical compounds.

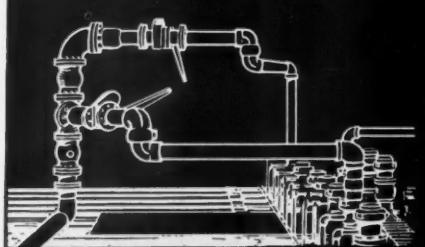


Eliminate fire and explosion hazards in lines handling Liquefied Petroleum Gases by using CHIKSAN *Ball-Bearing* Swivel Joints and all-steel lines.

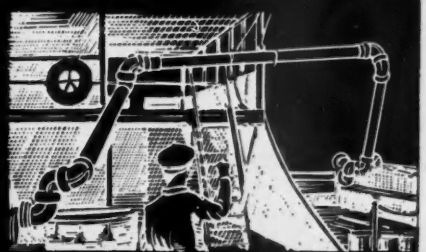
It's safer...and less expensive ...to insure safety *all* the way in your loading and unloading lines. With CHIKSAN *Ball-Bearing* Swivel Joints, you get the same strength...the same safety ...the same protection throughout your entire piping system because you can build your own flexible loading and unloading lines with pipe and fittings of the same strength and long life as you design and build into all other parts of your piping system. You eliminate all weak links! You eliminate all the variable hazards which increase with age and usage in all types of fabric or flexible metal hose.

Play safe *all the way!* Use CHIKSAN *Ball-Bearing* Swivel Joints to make up your loading and unloading lines. With them, you get unlimited flexibility with the strength, long life and safety of steel. You get greater protection...greater safety ...and greater economy with CHIKSAN.

CHIKSAN's Engineering Department will gladly assist you in designing flexible lines to suit your individual needs. This Service is based on 25 years of experience in designing and developing Ball-Bearing Swivel Joints for every purpose.



Transfer lines using CHIKSAN *Ball-Bearing* Swivel Joints save cost of extra valves and fittings...eliminate contamination losses.



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PAGE 260

MEN IN THE INDUSTRY NEWS

John M. Vetter has been elected vice president of Pan American Production Company, and will continue as assistant manager of the company but relinquishes his duties as assistant manager of the Pan American Gas Company.

Vetter joined Pan American Production in 1935 as chief geologist. He was later made superintendent of land and geology and then went into administrative activities.

A. C. Golden, Jr., has been appointed manager of Pan American Gas Company, and will continue as assistant to the vice president of Pan American Production. Golden joined the production company in 1938.

•

William D. Mason, director in charge of industrial relations, Sun Oil Company, has retired after 45 years in the oil industry. Mason will continue on the board of directors until the stockholders' meeting in April.

William D. Mason

The board has appointed **William E. Zimmerman** to succeed Mason. Zimmerman has been with the company since 1937, and was previously assistant manager of the Industrial Relations department. Mason joined the company in 1926 and has been a member of the board of directors since March, 1947.

C. Elmer Townsend, manager of Sun's Insurance department for the past 31 years, has retired.

Malcolm James, Houston has been promoted to chief scout of the Gulf Coast division and district landman of the Beaumont district. James joined Sun in 1926, became a scout in 1932 and was named chief scout for the Gulf Coast in 1948.

Raymond H. Weaver has been made chief scout for the Southwest Production division. He succeeds **John H. Langston,** who has been transferred to the Cashier's department at the Dallas office. Weaver, who started with the company in 1924, was formerly landman for the Tallahassee district.

•

Dr. Ionel I. Gardescu and **Curtis Morris** have been elected vice presidents of Transcontinental Gas Pipe Line Corporation.

Dr. Gardescu joined the company early in its history as head of the Gas Reserve department, and will be in charge of gas reserves as vice president.

Morris, who was with the East Texas Chamber of Commerce before joining the company in April, 1949, will direct public relations.

•

L. F. McCollum, president, Continental Oil Company, Ponca City, Okla., has been elected to the board of directors of J. P. Morgan & Company, New York.

C. W. Hamilton

Claude Woessner

Claude Woessner has been appointed general manager of Gulf Oil Corporation's Foreign Production division, and will assist **C. W. Hamilton,** vice president in charge of foreign production.

Other appointments in the reorganized department included **Edward S. Bleecker,** manager of Western Hemisphere operations; **R. E. Westling,** executive assistant in charge of technical matter for Western Hemisphere; **Aubrey W. Schofield,** manager Eastern Hemisphere operations; **Chester A. Baird,** assistant manager Eastern Hemisphere; and **E. E. Ferrin,** executive assistant in charge of technical matters for Eastern Hemisphere.

•

Miss Irene Gadelman, assistant secretary of Stanolind Pipe Line Company, Tulsa, has retired after 26 years of service. She went to Tulsa in 1923 as executive secretary for Sinclair Pipe Line Company, which later became Stanolind Pipe Line Company, and was appointed assistant secretary in 1946.

•

Frank C. Anderson has been appointed assistant to the vice president and assistant secretary of Gulf Oil Corporation and Gulf Refining Company. He succeeds L. E. Delcuze, retired.

Frank C. Anderson

Anderson, who was previously staff assistant and assistant secretary in the Executive department, joined Gulf as an office boy in 1933. He received his LL.B. degree in 1936 and became a certified public accountant in 1947.

•

David D. Irwin, Chicago, vice president for transportation and supply of The Pure Oil Company, has relinquished his full time responsibilities but continues in an advisory capacity. He has been with Pure 15 years.

Kenneth A. Covell, assistant vice president for transportation and supply, assumes the duties formerly carried on by Irwin. Covell has been with the company 17 years.

MEN IN THE INDUSTRY NEWS

L. L. Jones has been made general superintendent of Warren & Bradshaw Drilling Company, Oklahoma City, and **Don O. Freeman** has advanced to executive assistant to the president, with headquarters in Tulsa and Oklahoma City.

Warren & Bradshaw Drilling Company and Coronado Oil Company have opened a division office for both companies in the Apco Tower Building, Oklahoma City. Three new districts have been opened, the Oklahoma-Kansas district, Norman, Okla.; West Texas-New Mexico district, Midland; and the Panhandle district, Borger, Texas.

•

F. E. Thompson

F. E. Thompson, formerly superintendent for various plants for Warren Petroleum Corporation, has been named safety engineer for Warren and will direct the company's entire program. Thompson started as a field man for Warren in Brown County, Texas, in 1928.

•

J. M. Bradley, technical assistant to the president of Interstate Oil Pipe Line Company, Tulsa, has been elected a director of Interstate.

Bradley's pipe line career began in 1922, when he joined Oklahoma Pipe Line Company. He subsequently worked for Standard Oil Company of Venezuela in South America, and for Plantation Pipe Line Company, before he joined Interstate in 1945.

•

W. F. Dunning, manager of Standard-Vacuum Oil Company's Marine department, has retired after a 40-year career in shipping and transportation. With Santa Fe railroad prior to World War I and the U. S. War Shipping Board from 1918 to 1920, Dunning has been in the oil industry for the past 28 years. He joined Standard-Vacuum in 1934 in his present position and served during World War II as chairman of the Near East-Far East Supply and Distribution Committee of the PAW. **J. M. B. Howard,** assistant Marine department manager since 1948, will succeed Dunning as head of the Stanvac tanker fleet.

W. F. Dunning

•

F. F. Elliott has been elected assistant treasurer of Standard Oil Company (Indiana). Elliott, who joined the company in 1930 as traveling auditor, was made assistant to the treasurer in 1948.

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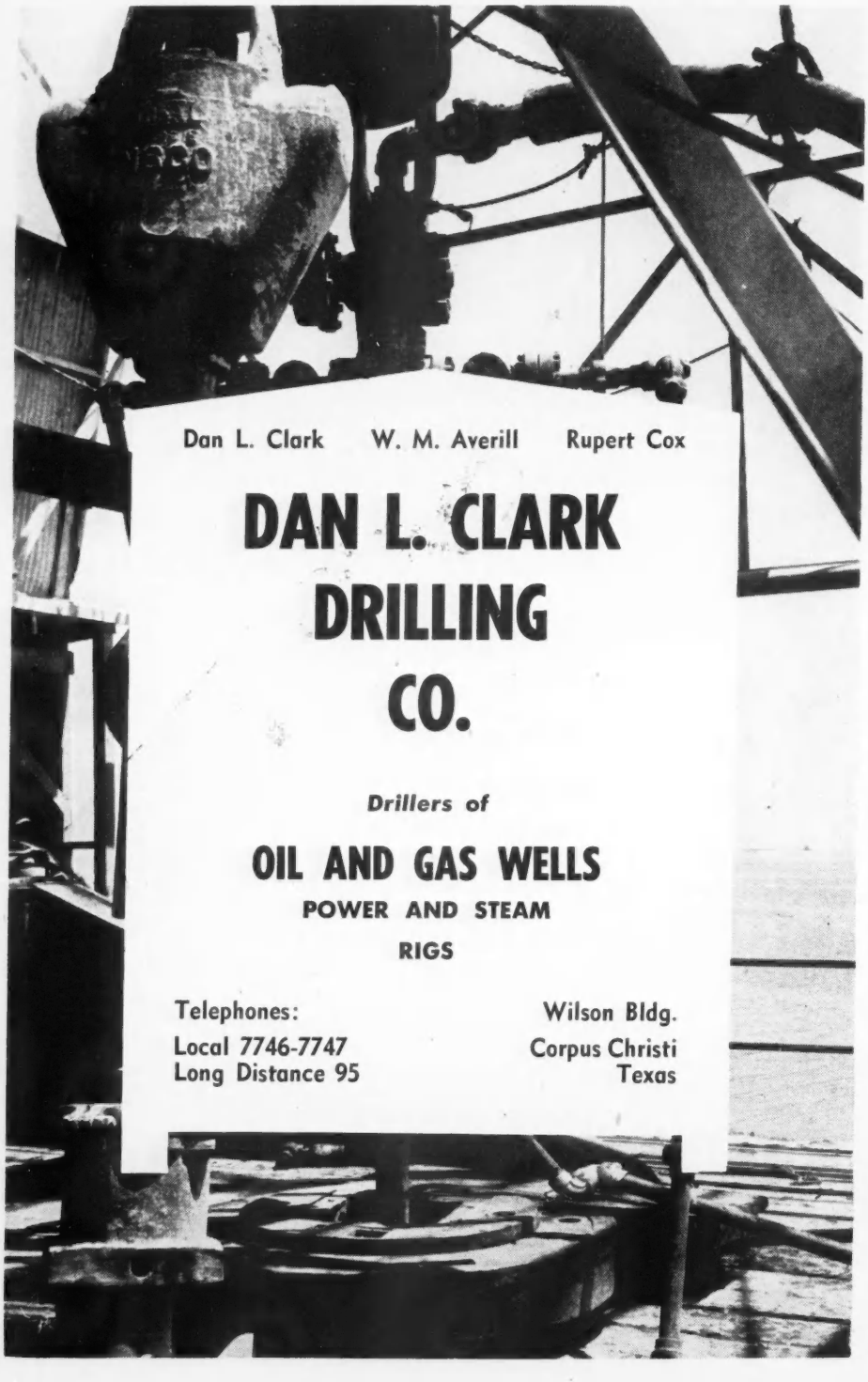
Transfers and Promotions:

Sinclair Oil and Gas Company made the following changes in its Production division: **Lawrence C. Stratton,** district superintendent, Drumright, Okla., promoted to assistant division superintendent, Fort Worth; **Kenneth E. Thornton,** district foreman, Pampa, Texas, promoted to district superintendent, Oklahoma City; **L. A. Bell,** district foreman, Bairoil, Wyo., promoted to assistant district superintendent, Oklahoma City; **William J. Rogers,** senior engineer, Arp, Texas, promoted to division engineer, Fort Worth; **John W. Hemphill,** senior engineer, Kiefer, Okla., promoted to division engineer, Independence, Kansas; **D. R. Dickson,** senior clerk, Midland, Texas, promoted to chief clerk of West Texas-New Mexico division, Midland; **Robert S. Fraser,** senior clerk, Tulsa, promoted to chief clerk, Kansas-Tri-State division, Independence; **James W. McFarlane,** senior clerk, Oklahoma City, promoted to chief clerk Oklahoma division, Oklahoma City; **Jewell L. Sumrall,** senior clerk, Houston, promoted to chief clerk of Sinclair's Texas Gulf Coast division, Corpus Christi, Texas; **Chester R. Richards,** intermediate petroleum engineer, Thrall, Kansas, promoted to district foreman; **Leslie D. Sellers,** assistant district foreman, Lindsay, Okla., promoted to district foreman; **Harold W. Shaner,** senior petroleum engineer, Ardmore, transferred to Midland; **H. F. Defenbaugh,** senior petroleum engineer, Lindsay, promoted to division petroleum engineer, Oklahoma City; **Ralph E. Smith,** district foreman, McPherson, Kansas, promoted to assistant district superintendent, Bristow, Okla.; **S. F. DeVore,** senior petroleum engineer, Shidler, Okla., transferred to Drumright; **Jerry A. Moran,** assistant district foreman, Bairoil, promoted to district foreman; **A. L. Lockhart,** pumper, Columbus, Texas, promoted to assistant district foreman; **Ellis T. Hammett,** intermediate petroleum engineer, Seminole, Okla., promoted to senior petroleum engineer, Arp; **Charles J. Eskridge, Jr.,** intermediate petroleum engineer, Delaware, Okla., promoted to senior engineer, Kiefer; **Charles L. Simmons,** intermediate petroleum engineer, Tulsa, transferred to Thrall. **Morris E. Brown** was promoted to senior clerk, Oklahoma City; **Martin G. Kale,** transferred to Lindsay, Okla.; **George R. Kelsey,** promoted to senior petroleum engineer, Oklahoma City; **Gibson S. Romberg,** promoted to division petroleum engineer and transferred to Corpus Christi; **R. F. Higginbotham,** promoted to district superintendent, Gainesville, Texas; **Hubert P. Erwin,** promoted to senior clerk, Gainesville; **Farrell F. Thomason,** promoted to district foreman, Pampa; **John F. Butler,** promoted to assistant district foreman, Bairoil; **Robert M. Irwin,** promoted to senior clerk, Casper; **Mahlon F. Manville,** promoted to intermediate petroleum engineer, Gainesville.

Albert S. Munneke, corrosion expert of Stanolind Pipe Line Company, has been transferred to the new post of Oklahoma area engineer, with headquarters at Shawnee, Okla. . . . Stanolind Oil and Gas Company has promoted **Roy S. Reed,** formerly industrial relations supervisor, North Texas-New Mexico division office, Fort Worth, to labor relations supervisor at the general offices in Tulsa; **Walter E. Forry** moved to Tulsa as personnel supervisor, from industrial relations in the Texas-Louisiana Gulf Coast division offices, Houston . . . **Wayman Moore,** formerly of Tyler, Texas, has been transferred to Evansville, Ind., as office manager for Delta Drilling Company. . . . **Frank Johnson,** formerly with Sohio Petroleum Company at Midland, Texas, has transferred to Evansville as district landman. . . . **Rycroft G. Moss,** field geologist for Phillips Petroleum Company, has transferred from Bartlesville, Okla., to Oklahoma City. . . . **R. Renn Rothrock,** Wellington, Kansas, has moved to Oklahoma City as district engineer for Sunray Oil Corporation.

Wade G. Moriarity has been transferred from the Salem, Ill., Producing district of Magnolia Petroleum Company to the Brownfield, Texas, district, as production superintendent. **Harvey Lee,** formerly production superintendent at Brownfield, has been transferred to Salem. **John Rice Guynes** has been promoted from buyer to assistant purchasing agent. . . . **H. C. Vanderpool,** chief geologist, Texas Pacific Coal and Oil Company, has been promoted to manager of exploration.



MEN IN THE INDUSTRY NEWS

J. R. Gignoux

C. A. Yeatman

J. R. Gignoux, chief mechanical engineer for Shell Oil Company, Los Angeles, has retired after 32 years of service. He joined the firm in 1918 as a draftsman at Oilfields, Calif.

C. A. Yeatman succeeds Gignoux as chief mechanical engineer. He formerly worked at Los Angeles as a field engineer. For the past year and a half he has been with Shell Pipe Line Corporation in Houston.

•

Emil J. Jandacek has been named assistant chief engineer of Texas Gas Transmission Corporation's pipe line system. He was previously with Stone & Webster Engineering Corporation and has also worked with the Tennessee Valley Authority.

Emil J. Jandacek

Jandacek is a graduate of the University of Wisconsin with a degree in civil engineering. His headquarters with Texas Gas will be at Owensboro, Ky.

•

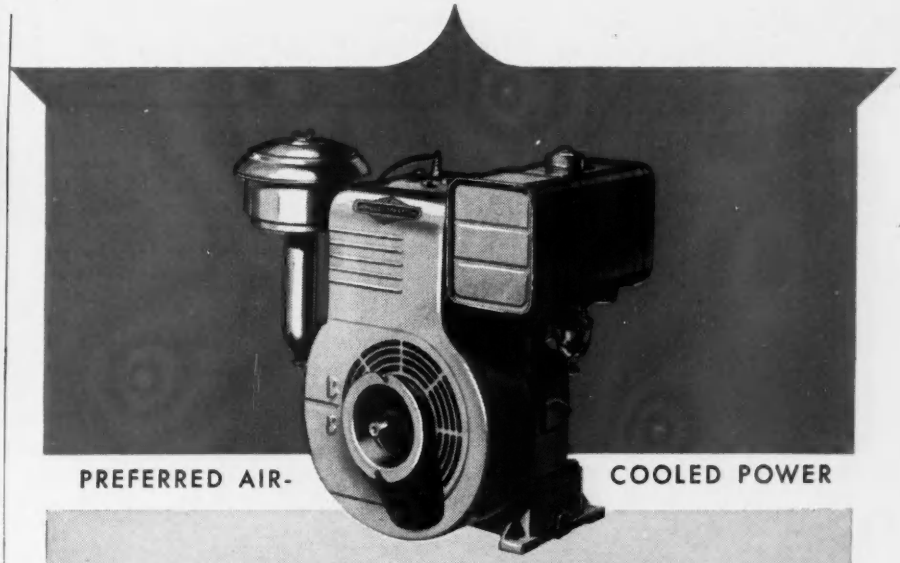
F. V. Cook, master mechanic, Stanolind Pipe Line Company, Tulsa, has been loaned to Trans-Arabian Pipe Line Company to help prepare an operating and maintenance manual for its mechanical equipment. He is stationed in San Francisco.

•

Don L. Hyatt, Oklahoma City, staff geologist for Sohio Petroleum Company, has resigned to head a new Exploration department for the Van - Grisso Oil Company.

Don L. Hyatt

Hyatt was with The Carter Oil Company 14 years, eight of which were spent in Ardmore and Seminole, Okla., as district geologist. He joined Sohio in 1943 as district geologist for Oklahoma and North and West Texas. For the past six months he has been staff geologist, making regional geological studies in the Mid-Continent area, Rocky Mountains and Canada.



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Bibb D. Haltom, 52, manager of the W. S. Farish Company, Houston, died in Houston December 26. Haltom became assistant to the president of Humble Oil & Refining Company after World War I, and in 1933, when **W. S. Farish,** then president of Humble, went to New Jersey to become president of Standard Oil Company (N.J.), Haltom went with him as his assistant. He returned to Houston ten years later as manager of the Farish company.

•

John Patrick Shannon, 77, Texas oil man, died December 28 in Battle Creek, Mich. Shannon, who worked in Pennsylvania and Ohio oil fields as a boy, was president of J. P. Shannon, Inc., Fort Worth.

DEATHS

J. A. Schallenberg, assistant comptroller, Worthington Pump and Machinery Corporation, died December 16. He had joined the corporation in 1918, and served in the Treasury and Accounting departments. From 1930 to 1937 he was special representative for the company in Paris.

•

J. R. Higgins, 73, president of J. R. Higgins Drilling Company and a partner in Higgins-Kreuger Drilling Company, died December 30. He had lived in Tulsa about 27 years.

E. W. Moutray, 74, partner and vice president of Moutray-Moore Drilling Company, died January 1 in Abilene, Texas. Moutray discovered the Weddington pool at Putnam, Texas, in 1924, and brought in the first well in the Belle Plains field at Baird, Texas, in July, 1926. He also brought in the first well in the Woodson field in Throckmorton County in 1929.

•

J. R. Simpson, 66, Tulsa oil operator, died January 1. He was president of the Home-Stake Oil and Gas Company and Home-Stake Royalty Company until his retirement in 1947, when he was named chairman of the board for both companies.

•

Thomas F. Brown, 62, Houston, First Aid Instructor for Gulf Oil Corporation, died January 11 at Beaumont. He resided in Houston 16 of the 21 years he was with Gulf. He previously had been with the U.S. Bureau of Mines for 12 years.

•

Herbert E. Nunnery, special representative of the American Petroleum Industries Committee of the API, died in Jackson, Miss., December 16. A graduate of the University of Mississippi Law School, Nunnery was appointed executive secretary of the Mississippi Petroleum Industries Committee in 1933, and served until 1942, when he joined the U. S. Army Air Force. He returned to the Mississippi committee in 1945, and was appointed by APIC in 1948.

•

C. Baggaley, 62, who had spent 15 years with Imperial Oil, Ltd., in South America, died in December in Vancouver, B. C. He was a bricking expert with Imperial before his retirement four years ago.

•

S. S. (Si) Stinson, 64, chief scout for Humble Oil & Refining Company's West Texas division, died January 9 in Brownfield, Texas. He was to have retired from the company January 10. Stinson was a former president of the National Association of Oil Scouts and Landmen and of the Midland Oil Scouts Association.

•

A. W. Lindley, retired general superintendent for Eason Oil Company, Enid, Okla., died in San Diego, December 28.

•

Francis Coryell, director of research, Interstate Pipe Line Company, Tulsa, died January 6. He joined Standard Oil Company (N.J.), in 1928 and was master mechanic in the Pipe Line department at Shreveport until 1943, when he was transferred to Tulsa.

•

R. D. Stauffer, 61, independent oil producer and drilling contractor, Tulsa, died January 7 in Colorado Springs. He had been active in the oil business in the Tulsa area since 1911 and had been part owner of Plymouth Petroleum Company until 1948, when he sold all but his drilling interests in the firm.

What's your wall scraping job? Removing mud cake?...Increasing diameter for gravel packing? Cementing? *You can do the job faster and better—for less—with the Grant Hydraulic Expansion Wall Scraper!*

Its simple, rugged construction insures long, trouble free service. Blade expansion by pump pressure is controlled entirely from the rig floor. Seven scraper body sizes cover the range from 4¼" to 36". Three types—bull-nose, bottom hole and diamond point—will meet your specific scraping requirements.

Your nearby Grant branch is ready to furnish the Wall Scraper you want for your next job, and a service man stands ready to assist in running and operating the tool—day or night. *Call Grant—write direct for Bulletin 20 giving full details—or see the Grant Section in the Composite Catalog!*

Proven Grant Tools—Used Where Performance Counts

Hydrostatic Bailers	Bulletin No. 11
Liner Pullers	Bulletin No. 14
Pressure Releases	Bulletin No. 15
Casing Scrapers	Bulletin No. 17
Wall Scrapers	Bulletin No. 20
Bottom Hole Scrapers	Bulletin No. 21
Underreamers (Rotary)	Bulletin No. 24
Underreamers (Cable Tool)	Bulletin No. 27
Hole Enlargers	Bulletin No. 38
Reamers	Bulletin No. 43
Hydrostatic Perforation Cleaners	Bulletin No. 50
Dump Bailers	Bulletin No. 51
Roller Cutter Shale Bits	Bulletin No. 54
Sand Pumps	Bulletin No. 55
Well Cleanout Equipment	Bulletin No. 57

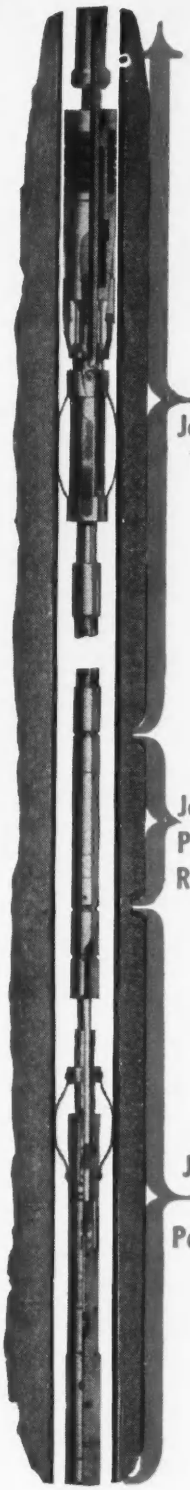
Write for Descriptive Bulletins on these Grant Tools

GRANT OIL TOOL COMPANY

Main Office and Plant
2042 E. Vernon, Los Angeles 11, Calif.
Branches Throughout California and The Mid-Continent

SHOOT-N-TEST

THE JOHNSTON *all purpose* GUN PERFORATOR



Gives you maximum PORTABILITY!

THE JOHNSTON GUN PERFORATOR is flexible in operation and so completely portable that the entire unit can be transported in your regular field car! For each perforating job you need only the Firing Head and the Perforating Gun Sections—no special depth measuring devices, firing equipment or extra assembling tools are necessary.

After delivering the Johnston Gun Perforator to the well, you can select the exact number of Perforating Gun Sections needed for the job. When the quantity of perforations is known, you simply attach the correct number of Perforating Gun Sections to the Firing Head and lower the entire unit on the bottom joint of tubing or drill string to the zone selected for perforation. Bottom-hole hydrostatic pressure fires the Johnston Gun Perforator automatically following definite rotary and vertical manipulation of the connecting string by the driller.

And if you want a formation and pressure test made on the same run of tubing or drill string, you simply connect the Johnston Gun Perforator to *your* regular Johnston Formation Tester and Pressure Recorder for *combined* perforate-and-test operations. It's the slickest possible way of obtaining water shut-off information, doing exploratory work or testing for actual production.

FLEXIBILITY and PORTABILITY

are only two of the *many* outstanding advantages of the Johnston "SHOOT-N-TEST" All Purpose Gun Perforator. Here are other important Johnston features to consider when contemplating Gun Perforator equipment . . .

SAFE gun perforator operation! The Johnston Gun Perforator will not fire until subjected to *both* in-the-hole hydrostatic pressure and positive rotary and vertical manipulation of the pipe string by the driller.

POSITIVE FIRE of all projectiles! The safe, fool-proof hydrostatic firing principle of the Johnston Gun Perforator coupled with the flash-hole design of the Perforating Gun Sections assures positive fire of all projectiles.

ANY NUMBER OF PERFORATIONS possible! Any number of four, five or six-shot Perforating Gun Sections can be attached to the Johnston Gun Perforator Firing Head to provide the *exact* quantity of perforations needed for each job.

EXACT POSITIONING in producing zone! Accurate placement of the Johnston Gun Perforator at the *exact* depth for perforating is easily determined by pipe-in-the-hole tally. No rigging-up of special measuring devices is necessary.

MINIMUM OF EXPENDABLE SUPPLIES! The Johnston Gun Perforator needs only a minimum of loading supplies for each perforating job. The Perforating Gun Sections require only seals, powder charges and projectiles for reloading.

FAST, EASY MAINTENANCE! The Johnston Gun Perforator is outstanding for its simplicity of operation and trouble-free construction. The simple procedure of disassembly, cleaning, loading and reassembly can be done right on the rig floor.

Write **for NEW DESCRIPTIVE FOLDER**
On The Johnston "SHOOT-N-TEST" Gun Perforator!

SHOOT-N-TEST Trademark — JOHNSTON FORMATION AND CASING TESTING

M. O. JOHNSTON OIL FIELD SERVICE CORP.
3035 Andrita Street, Los Angeles 41, California
"Servicing California-Permian Basin-Rocky Mountain Areas"
BRANCHES
Bakersfield, Avenal, Sacramento, Ventura, Santa Maria, Cal.: Odessa, San Angelo, Tex.; Casper, Wyo.; Hobbs, N.M.

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5702 Navigation Boulevard, Houston, Texas
"Servicing Mid-Continent and Gulf Coast Areas"
BRANCHES
Abilene, Alice, Cisco, Graham, Throckmorton, Tyler, Victoria, Wichita Falls, Texas; Lake Charles, Louisiana; Magnolia, Arkansas; Laurel, Natchez, Mississippi; Chickasha, Oklahoma; New Harmony, Indiana; Fairfield, Illinois

EQUIPMENT AND SERVICE SUPPLIERS' NOTES

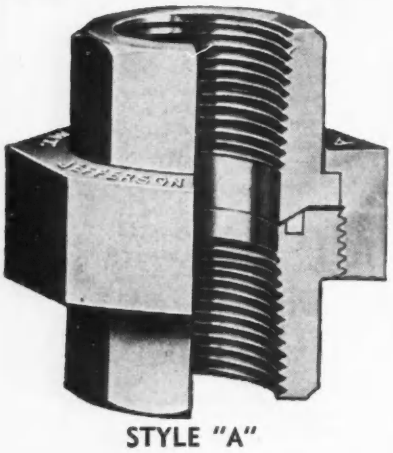
DRESSER INDUSTRIES sales and engineering officials, representing the 11 subsidiary companies, are pictured at a luncheon and conference in Chicago. The meeting was presided over by J. B. O'Connor, executive vice president of Dresser Industries, Inc.

Republic Announces New Assignments, Division of Gulf Coast District

Republic Supply Company's District No. 2, which formerly included the Texas and Louisiana Gulf Coast area, has been split into three parts. H. C. Kinney, manager of District No. 2, has moved from Houston to San Antonio. The district now includes stores at Corpus Christi, Alice, Hebbronville, McAllen, Pleasanton, Falfurrias and Victoria. Houston and the surrounding trade territory are in the Houston district and are under the management of Ralph B. Harp.

W. M. Haynes will supervise the New Iberia and Lake Charles, La., stores, which were formerly part of District No. 2. Haynes is also manager of refinery and industrial sales for Republic.

Jefferson Malleable Unions



STYLE "A"

JEFFERSON Style "A" Unions and Style "A" Union Fittings can be furnished with Brass-to-Iron, and Iron-to-Iron Seats.

HYDRAULIC PRESSURE RATING

Sizes	*Test Pres.*	*OWG*	*SWP*
⅛" thru 2"	4000#	1500#	500#
2½"	3000#	1200#	300#
3" thru 4"	2000#	800#	300#

Our "Iron-to-Iron seat" unions are highly recommended and especially desirable where sulphur content of oil is high; also for chemical services where acid-bearing liquids or gases require the use of iron fittings. AIR FURNACE IRON, having a much denser and finer grain structure, gives a dependable and positive seating surface—ASTM-4733-Grade 35018-53000-lb. M.T.

Obtainable through your jobber

Jefferson Union Company, Inc.

691 West 26th St.,
New York 1, New York

71 Gooding St., Lockport, New York — 31 Fletcher Ave., Lexington 73, Mass.

World Freight Service from Gulf Announced by Shipping Concern

A world-wide ocean freight service from all principal Gulf ports has been inaugurated by Gulf Shipping Lines, agents and chartering brokers.

Representing independent steamship lines on a non-conference basis, the company will schedule regular sailings from Houston, Galveston, Brownsville, Corpus Christi, Beaumont, Port Arthur, Lake Charles, New Orleans and Mobile to ports in the west Indies, the Persian Gulf and the Orient. The non-conference rates apply to all classes of cargo, including bulk cargoes.

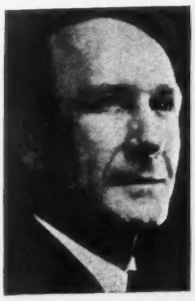
To assist exporters in the development of sales in foreign lands, the main office at Houston and branch offices of Gulf Shipping Lines offer information and consultation services based on daily contact with export markets throughout the world.

A. D. (Bud) Lee is president of the company. He is also president of Lee Construction Company, World Development Company and American Supply and Equipment Company, as well as an independent oil operator. T. J. Stevenson, vice president of Gulf Shipping Lines, has had 40 years' experience in directing freighter and liner operations. He is president of the Stevenson Line, which maintains regular berth services out of North Atlantic ports to the Mediterranean Sea and the Persian Gulf.

Hughes Officials Return from Trip

M. E. Montrose, vice president-sales, Houston; W. H. Siems, export sales manager, New York; and R. G. Roberts, London representative of Hughes Tool Company, have returned to their respective headquarters after an extended busines trip through England, France, the Netherlands, Germany and Italy.

EQUIPMENT and SERVICE SUPPLIERS' NOTES



G. C. Bukowsky

E. A. Trask

Roebling Assigns Trask and Bukowsky To Chicago and San Francisco

E. A. Trask, former head of the San Francisco office of John A. Roebling's Sons Company of California, has been made manager of sales of the company's Chicago corporation. G. C. Bukowsky, former manager of the Portland, Ore., branch, succeeds Trask.

Both Trask and Bukowsky have been with the company since 1925.

Houston Bank of Commerce Names Two to Administrative Positions

Robert W. Kneebone has been named vice president of the National Bank of Commerce, Houston. He was a staff member of the American Bankers Association and most recently was managing director of the National Automobile Dealers Association, Washington, D. C.

James P. Simmons, a member of the bank's credit department since March, 1948, was elected an assistant vice president, and Ovide Eugene Boulet, a National Bank of Commerce employe for 18 years, was named a trust officer.

Metallurgist Joins Tesco at Houston

Horace R. McCoy, formerly chief metallurgist for Ohio Steel Foundry Company, Lima, O., has been appointed metallurgist for Texas Electric Steel Casting Company. McCoy is a chemical engineer graduate of Western Reserve University, and has taken post graduate work in metallography and heat treating of iron and steel at the Case School of Applied Science. He is a member of the Steel Founder's Society and AIME.

Horace R. McCoy

DeLong Heads Waukesha

The board of directors of Waukesha Motor Company elected J. E. DeLong president of the company. Other officers are J. G. Swain, vice president; C. P. Ross, secretary-treasurer; C. E. Nelson, vice president; and L. W. Youker, assistant secretary and assistant treasurer.

NEW BRANCH SALES STORE of Oil Well Supply Company, at New Iberia, La., is under the management of John D. Boggs, Jr. The store is in the Southeast Texas district.

Petroleum Consultants Firm Offers Exploration Contracting Service

T. A. Manhart, Carl W. Blakey, J. L. Friendly and Fred W. McMahon, have formed an exploration contracting company, Petroleum Consultants, Inc., with offices in the McBirney Building, Tulsa, to offer the oil industry geological and seismic services on a contract basis.

At the first directors' meeting Manhart was elected president, Blakey and Friendly, vice presidents, and McMahon secretary-treasurer. All officers with the exception of McMahon, who formerly was with Deep Rock Oil Corporation, were formerly with Seismograph Service Corporation, Tulsa. Clark Millison, consulting geologist, Tulsa, will perform the geological services for the new company.

Welded Steel Pipe Mill Planned

A new electric welded steel pipe mill will be constructed at National Works of National Tube Company at McKeesport, Penna. The new facilities will provide for an annual capacity of 100,000 net tons of 26-inch and larger diameter electric welded and expanded steel pipe. The pipe will be produced in 40-foot shipping lengths.

Garlock Vice President Retires; His Successor Is Appointed

Phil Arnold, vice president of The Garlock Packing Company, has relinquished his duties in charge of the General Sales department, but continues in a partially active capacity as vice president. Arnold has been with Garlock 41 years, and has been vice president since 1929.

Louis Mohn has been named general sales manager, with headquarters in Palmyra, N. Y. He was previously district sales manager at Pittsburgh, and is succeeded there by Eugene C. Flannery.

Spang-Chalfant Division Appoints E. A. Booth General Sales Manager

Edwin A. Booth

The National Supply Company has appointed Edwin A. Booth as general manager of sales of the Spang - Chalfant division. He has been with the company since 1929.

Booth is a graduate of Pennsylvania State College. Before his recent appointment, he was manager of the Pittsburgh sales district.

FOR DEEP OR SHALLOW DRILLING...

GEOLOGRAPH
MECHANICAL WELL LOGGING SERVICE CAN HELP YOU!

Even in *shallow* drilling, you save when you log as you drill with Geograph. You make it as "painless" as possible because Geograph's foot-by-foot record shows when the bit is dull; gives more hole per bit and in less time; shows depth, connections and down time!

ODESSA, TEX. • WICHITA FALLS, TEX. • BAKERSFIELD, CALIF.
SHREVEPORT, LA. • BATON ROUGE, LA. • CASPER, WYOMING

GEOLOGRAPH TIME WILL TELL

"TIME WILL TELL"
THE GEOLOGRAPH CO. INC.
P O Box 1291 Oklahoma City 1, Okla.

here comes MOUNTAIN IRON with that Thread Dope!

"Those guys at Mountain Iron will do anything to make a customer happy!" I hope the boss buys Pittsburgh pipe for the oil string . . . I want to see how they handle that. Can of dope or string of pipe—*the service is most important to us.*

Kansas Stores Located at
MADISON ▪ McPHERSON ▪ CHASE ▪ RUSSELL ▪ PLAINVILLE
HOME OFFICE—PARKERSBURG, W. VA.
SALES OFFICE—TULSA, OKLA.

MOUNTAIN IRON
MOUNTAIN IRON AND SUPPLY COMPANY
714 Fourth Nat'l Bank Bldg. ▪ Wichita, Kansas

EQUIPMENT and SERVICE SUPPLIERS' NOTES

CUTTING THE RIBBON to open the new D+B plant at Garland, Texas, are, left to right, W. T. Powell, vice president of Emsco Derrick & Equipment Company; Mrs. W. T. Powell; W. C. Kinder, vice president, Emsco; Mrs. Hugh H. Glen; and Hugh H. Glen, president of Emsco.

National Assigns Representative To Tulsa General Sales Staff

The National Supply Company has transferred L. S. Ousterhout of Tulsa from the Oklahoma division to the general sales staff of the company. His new duties will concern application of National's equipment, including the Ideal plunger lift, to deep well pumping.

L. S. Ousterhout

Ousterhout, who joined National Supply Company in 1931 as production equipment sales representative, has been stationed in Tulsa since. 1935. He has been associated with the oil business since 1920.

Stacey-Dresser Moves to Cincinnati

Stacey-Dresser Engineering division, Cleveland, has moved its headquarters to Cincinnati. E. A. Flaschar, general manager of Stacey-Dresser, will direct the coordination of the activities of his organization with those of the parent company, Stacey Brothers Gas Construction Company, a subsidiary of Dresser Industries, Inc.

Production, Service Manager Named

Bethlehem Supply Company of California has appointed P. B. Erwin as manager of production and services. J. C. Graves, Jr., has been named manager of machinery sales to succeed Erwin.

ALTEN

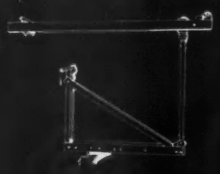
PUMPING UNITS

are better

why **"Alten units will pump more fluid at a lower cost". That's what profit conscious operators everywhere are saying.**

how **Alten units are built from the *inside out* to deliver longest dependable service under hardest conditions of continuous use.**

ASK FOR THE COMPLETE ALTEN LINE



Pumping Jacks

Stop Cocks

Casing Heads

AT YOUR INDEPENDENT SUPPLY STORE

ALTENS FOUNDRY & MACHINE WORKS, INC.

LANCASTER, OHIO, U. S. A.

ALTEN

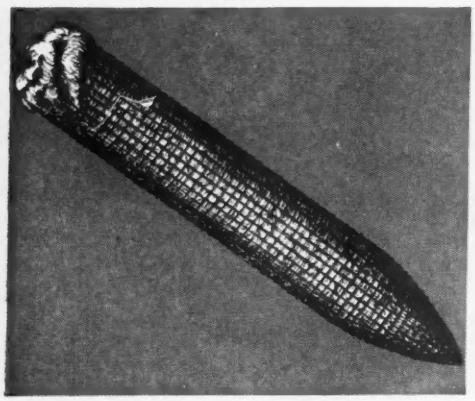
General Superintendent Named At National's Torrance Plant

W. R. Patterson has been appointed general superintendent of the Steel department at the Torrance, Calif., plant of The National Supply Company. Patterson will continue as chief plant metallurgist.

The Steel department at Torrance includes electric furnace facilities for producing special alloy steels and also complete forge and foundry equipment. In addition, National Supply produces a major part of its heavy duty rotary drilling equipment for the oil industry at Torrance.

H. E. Heywood, Jr., has been appointed assistant chief engineer of the Toledo, O., plant of The National Supply Company. Heywood is a graduate mechanical engineer from Oklahoma A & M College. He secured his masters degree in mechanical engineering from California Institute of Technology in 1940. At that time he came with National Supply and has since been associated with the Engineering department at Toledo.

R. W. (Bob) Craig, sales engineer, Torrance, is on a three-month trip through the Middle East, going by way of England to visit the company's subsidiary plant, Oil Well Engineering Company.



Don't risk Bottom Water shutdowns

Eagle-Picher Lead Wool

shuts out Bottom Water!

Prevent costly shutdowns, keep bottom water out of your wells with effective, economical Eagle-Picher Lead Wool. The fine, durable strands fill cracks and crevices with a permanent, non-corrosive seal...save you time and money. Packed in convenient 50-pound sacks — easy to place in special cartridge-shaped Eagle-Picher Wire Containers sized to fit all casings. Order through your jobber today!

These 3 Eagle-Picher Bearing Metals meet most requirements

Dreadnaught — for extreme speed and heavy-duty conditions.

Outlasta — for medium speed and average-load conditions.

Durable—for low speed and light-duty conditions.

EAGLE-PICHER LEAD WOOL

Seals off Bottom Water— keeps 'em flowing!

THE EAGLE-PICHER COMPANY

EAGLE Since EP 1843 PICHER

Cincinnati • East St. Louis
Chicago • Kansas City • Dallas

John E. Eckel

Marvin R. Jones

Houston Engineers Organize Firm To Develop New Oil Field Tools

John E. Eckel, formerly vice president in charge of engineering, Oil Center Tool Company, and Marvin R. Jones, former chief engineer of the same company, have formed The Petroleum Mechanical Development Company at 3803 South Main Street in Houston. The organization has facilities for manufacturing new oil tools, and the firm will also act as consulting petroleum mechnical engineers. Tools will be sold under the trade name "Petromec."

Eckel, the company's president, has had 20 years experience in oil equipment engineering with Humble Oil & Refining Company and O-C-T.

Jones, who is secretary-treasurer, has done tool designing work with American Iron and Machine Works, Hughes Tool Company, Cameron Iron Works, and O-C-T.

Middle West Coating and Supply Firm Is Organized in Tulsa

Maynard H. Jackson has announced the opening of Middle West Coating and Supply, a Tulsa firm which will deal in corrosion mitigation products, including Koppers cold coatings and Oklahoma Glass Fiber reinforcement.

Maynard H. Jackson

Jackson resigned as sales manager of standard pipeprotection, inc., to form the new company. He had previously been with Johns-Manville Company and Hill, Hubbell & Company. He is a past general chairman of NACE and is now a member of the board of directors.

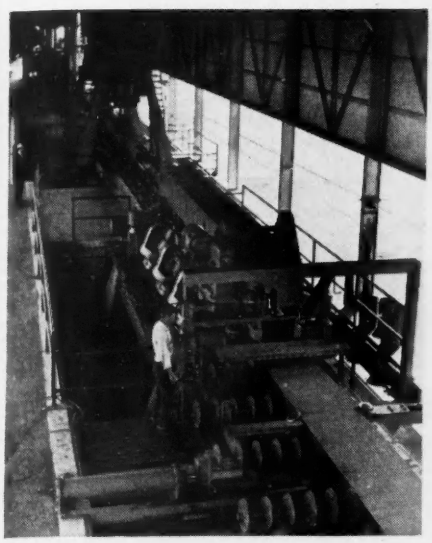
Clark Names Advertising Manager

Charles Graff has been named advertising manager of Clark Bros. Company, Inc., Olean, N. Y., to succeed the late John L. York.

Neal Joins Huber Corporation

C. R. Neal, formerly with Cities Service Oil Company at Great Bend, Kansas, has joined the geological staff of the J. N. Huber Corporation at Wichita.

EQUIPMENT and SERVICE SUPPLIERS' NOTES



THE FIRST FORMING operation in the manufacture of steel plate into Basalt-Kaiser pipe at the Basalt Rock Company plant at Napa, Calif., is shown here. In right foreground a 40-foot section of plate is entering the edge-forming or crimping machine. Next in line is the press where plate is subjected to top and side pressure to give it a U shape. At the far end of the line is the main press where the U section is pressed into circular form.

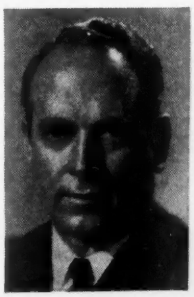
Basalt and Kaiser Announce Plan To Produce Large Diameter Pipe

A manufacturing and sales agreement which will increase West Coast production of large diameter steel pipe for the pipe line industry was announced jointly by Kaiser Steel Corporation and the Basalt Rock Company.

Plate for the pipe will be supplied from the Kaiser Steel mill at Fontana, Calif. The Kaiser Steel sales organization will market the steel pipe produced at Napa under the label "Basalt-Kaiser" steel pipe.

Western Company General Counsel Moves to Midland Headquarters

Herbert Marshall, vice president and general counsel of The Western Company, has moved his office from Dallas to the company's headquarters in Midland.



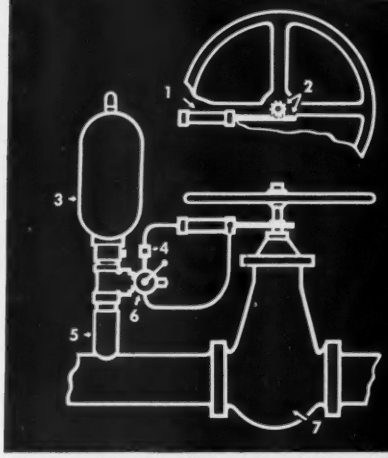
Herbert Marshall

Marshall had practiced the legal profession in Dallas for 17 years and was a partner in a law firm there. He has specialized in oil and gas law, insurance law, and tax law work. He plans to continue to do some outside practice in Midland in addition to handling his executive duties with The Western Company.

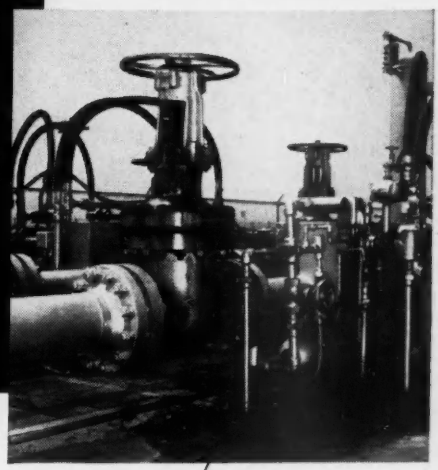
Dayton Exploration Names Manager

Jack Gallacher, formerly with Key Velocities, Inc., is now party manager for Dayton Exploration Company, Tulsa.

HUGE PIPE LINE SHUT-OFF VALVES OPENED BY REMOTE CONTROL



(1) Hyd. Act. Cyl. (2) Actuating Linkage (3) Accumulator (4) Flow Control Valve (5) Check Valve (6) 4 Way Directional Control Valve (7) Pipe Line Shut Off Valve.



Thousands of shut-off valves ranging in sizes up to 20-inch port diameter, standing as high as 7 feet and weighing up to 7000 lbs are used by the petroleum industry to control fluid flow through miles upon miles of pipe lines. Manual operation of these huge valves is virtually impossible. Furthermore, the location of some makes them hard and hazardous to-get-to.

This problem has been effectively solved by Greer Hydraulics. A hydro-pneumatic accumulator teed into the pressure line utilizes system pressure to open and close these valves.

System pressure is stored in the accumulator for ready use to do the actual work when the valve has to be opened or closed. A selector valve, remotely controlled from a finger-tip actuated pilot valve or solenoid, directs pressure fluid from the accumulator to an actuating cylinder to open or close the shut-off as desired through a rack and pinion arrangement on the valve handle. A positive flow control in the line prevents rapid valve action thus eliminating dangerous line surges.

In addition to its positive action this system eliminates the fire hazard of electric motor actuated valves and the necessity of an external power source for pneumatic-actuated shut-off valves.

Write for details today.

United States Patents Under Olear Licenses

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

YOUR SYMBOL OF SERVICE

GREER

HYDRAULICS INC.

454 EIGHTEENTH ST., BROOKLYN 15, N. Y.

HUGHES CANADIAN OFFICIALS photographed with the Hughes Tool Lockheed plane in Canada are, left to right, M. E. Montrose, vice president—sales, Houston; W. L. Hunter, Northern region manager, Oklahoma City; S. J. Lintzenich, Rocky Mountain division manager, Casper; H. E. Snelson, Canadian district manager, Calgary; R. T. Helmer, Canadian sales representative, Calgary; E. R. Woodmansee, manager tool joint sales, Houston.

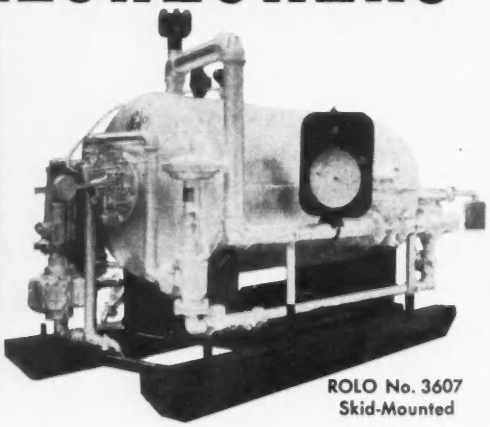
Harvester Industrial Power Announces Engineering Changes

Appointments in the Industrial Power division of International Harvester Company include that of W. O. Bechman, as chief engineer, advanced engineering group; M. R. Bennett, chief engineer, product engineering group; H. V. Parsley, chief engineer, government engineering group; and J. W. Curley, chief engineer, experimental and test group.

The reorganized functions of industrial power engineering will be under the direction of D. B. Baker, manager of engineering.

ROLO WELLCHECKERS

Permanent and Portable Oil and Gas Separators



ROLO No. 3607
Skid-Mounted

Rolo Wellcheckers are made in all sizes to fit any operation

Don't let rain or winter snows make the job of setting separators a problem. Rolo Wellcheckers, completely piped and ready to operate, perform dependably in all climates, in fields throughout the world. Designed for gas-lift, flowing and pumping wells, Rolo Wellcheckers are used by 23 majors, numerous independents, and are approved by regulatory bodies. Write for illustrated catalog.

OIL WELL METERING SPECIALISTS

ROLO MANUFACTURING COMPANY

2235 2510 SOUTH BLVD., HOUSTON 6, TEX.

BRANCHES: Midland, Kilgore, Tulsa, New Orleans, Casper, Edmonton, Alta.
EXPORT OFFICE: R. S. Stokvis & Sons, Inc., 17 Battery Place, New York, N. Y.

Bethlehem Supply Appoints Fort Worth Representative

Charles E. Medley has joined Bethlehem Supply Company as special representative for pumping units and other production equipment at Fort Worth. Medley attended the University of Tennessee, where he majored in mechanical engineering before he went into the armed forces in World War I. He has had more than 20 years experience in the manufacture and sale of oil field equipment.

Charles E. Medley

American Manufacturing Company Names Manager of Tulsa Office

Virgil R. Cloer has been appointed manager of the Tulsa office of The American Manufacturing Company of Texas, G. L. Messer, vice president, announced. The new branch was opened in the Hunt Building to serve northern Oklahoma and Kansas.

Virgil R. Cloer

Cloer was with Rector Well Equipment Company before joining American and has had field experience with major oil companies and drilling contractors. He attended Texas Christian University.

Tulsa Attorney Will Specialize In International Tax Affairs

John S. Carlson, general counsel for Seismograph Service Corporation, Tulsa, has opened an office in the McBirney Building, Tulsa, to conduct the general practice of law specializing in corporate, income tax and general tax problems and matters involved in the conduct of international business. Carlson has had experience in legal affairs affecting American companies operating in Canada, Mexico and South America and in connection with obtaining income tax exemptions for American nationals working in foreign countries. He has resigned as secretary of Seismograph Service, but will continue to serve as a director and general counsel.

John S. Carlson

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Engineering Director Is Chosen By Fairbanks, Morse & Company

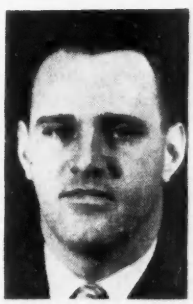
Fairbanks, Morse & Company has appointed Frank M. Mason, Jr., as director of engineering, with offices at the firm's headquarters in Chicago.

Frank M. Mason, Jr.

Mason, who has for several years been manager of the Research division in charge of all research, developments and patents, joined the company in 1922 following his graduation from Northwestern University, the Massachusetts Institute of Technology and Washington University. He was first employed in the engineering department of the company's Indianapolis plant. In 1923 he was transferred to St. Louis to organize a patent department for the firm. In 1925 he entered the Research division in Chicago and became successively assistant manager in 1940 and manager in 1946.

Mud Consultant Will Serve San Joaquin Valley Area

Ed Steele, former San Joaquin Valley manager for Oil Base, Inc., has opened a mud consulting office at Bakersfield, Calif., to serve San Joaquin Valley fields.



Ed Steele

Steele was previously manager in California for Baroid Sales division, National Lead Company, manager for Macco Antelope Materials Company, and mud engineer for Bell and Loffland in the California territory. He recently conducted the mud school for the AAODC in Bakersfield.

Lane-Wells Wins Advertising Award

Lane-Wells Company was voted "Best of Industry" in the oil tool classification by the board of judges at the 32nd Annual Convention of the Direct Mail Advertising Association in Chicago. The Lane-Wells exhibit included the publications "Tomorrow's Tools—Today!" "Lane-Wells Cablegram," the "Round Table," bulletins, catalogs, stockholder reports, and other direct mail pieces.

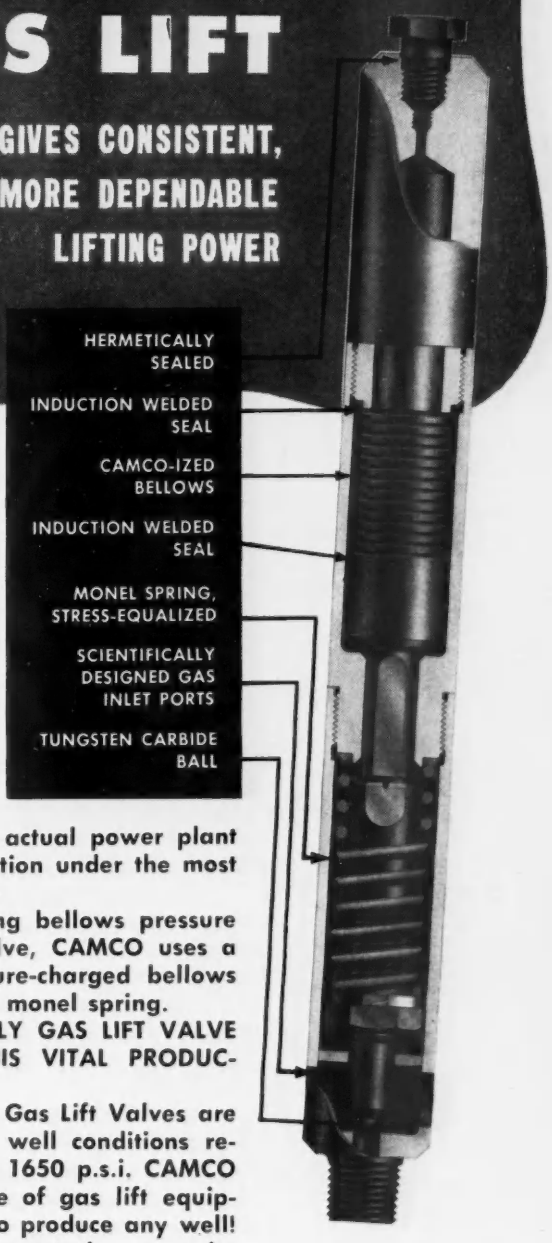
Roebling Opens Denver Office

John A. Roebling's Sons Company, Trenton, N. J., has opened its new Denver office and warehouse at 4801 Jackson Street. Homer H. Davis, Roebling representative in Denver for 23 years, is manager, with Roy H. Hainsworth as assistant. Fred L. MacLean is in charge of oil field sales.

CAMCO

GAS LIFT

CAMCO-IZING GIVES CONSISTENT, MORE DEPENDABLE LIFTING POWER



CAMCO-IZING . . . an exclusive CAMCO process . . . is the only answer to consistent, dependable lifting power and economical gas-fluid ratios available in gas lift equipment today.

CAMCO-IZING preforms the valve bellows with 5,000 lbs. differential pressure. Thus, it tests while it conditions the valve's actual power plant for correct, positive action under the most severe well conditions.

And instead of using bellows pressure alone to close the valve, CAMCO uses a combination of pressure-charged bellows and a stress-equalized monel spring.

CAMCO IS THE ONLY GAS LIFT VALVE WHICH PROVIDES THIS VITAL PRODUCTION INSURANCE.

Hundreds of Camco Gas Lift Valves are installed today under well conditions requiring from 125 thru 1650 p.s.i. CAMCO makes a complete line of gas lift equipment . . . equipment to produce any well! Ask your Camco Representative or write Camco, Inc., 1108 Scanlan Bldg., Houston, for help with your production problems.

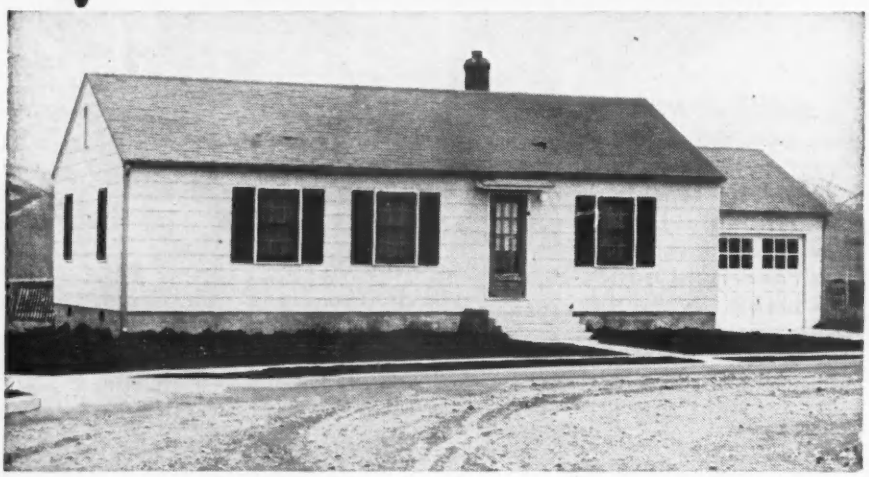
Your copy of the new Camco Catalog is now ready. Write for it today

CAMCO

GAS LIFT EQUIPMENT AND SERVICE

REGIONAL REPRESENTATIVES from the Canadian, New England, New York and Philadelphia sales divisions of Oakite Products, Inc., are pictured at the company's Technical Sales Conference in New York. Similar conferences were held for Oakite representatives from Chicago, Cleveland, the Midwest, Milwaukee, St. Louis and Southern divisions, and from the North Pacific, South Pacific and Southwestern territories.

STURDYBILT Houses pre-tested for 30 YEARS



The "pre-testing" of STURDYBILT Prefabricated Houses was done 30 years ago in the oil fields of Oklahoma. Continued improvements have made STURDYBILT Houses remain first in value in oil field housing. Write for information.

PREFABRICATED HOME MANUFACTURER 30 Years

MANUFACTURERS OF SPECIAL MILLWORK; DISTRIBUTORS OF JOHNS-MANVILLE BUILDING MATERIALS; CURTIS WOODWORK

STURDYBILT

SOUTHERN MILL & MANUFACTURING CO.
Tulsa, Oklahoma

Prefabricated, Demountable Houses

phmi PREFABRICATED HOME MANUFACTURERS' INSTITUTE

STURDYBILT HOUSES COMPLY WITH COMMERCIAL STANDARD CS125-45 OF THE NATIONAL BUREAU OF STANDARDS FOR PREFABRICATED HOMES

Davies Is Appointed Director Of Caterpillar Tractor Research

J. M. Davies, associate director of research at Caterpillar Tractor Company, has been named director of research, succeeding C. G. A. Rosen who remains with the company in an advisory capacity.

J. M. Davies

Davies has been with the company since 1925 when he joined the firm at San Leandro, Calif., as a laboratory engineer. Later he became a research engineer at San Leandro and was transferred in the same capacity to Peoria in 1933. In 1939 he was promoted to assistant chief engineer and to assistant director of research in 1942. His appointment as associate director of research came in 1945.

Succeeding Davies will be Dr. L. A. Blanc who has been assistant director of research, administering the activities of the physical, chemical and metallurgical division. He joined Caterpillar at San Leandro in the research organization in 1937.

Falcon Vice President Returns From Lengthy Tour Through U. S.

A return to a more normal state of business is seen by W. G. Wellington, vice president-chief engineer, Falcon Products, Inc., upon completion of several months' travel throughout the U. S.

W. G. Wellington

"There is nothing wrong with the oil industry," claims Wellington. "We are probably now, after many years of accelerated demand for products, just beginning to reach a point in our economy where the advantages of a free enterprise system are showing up. Buyers are shrewd and more than ever demand a dollar value for the dollar spent. Overstocked inventories are being worked down," says Wellington; "and from here on in highly competitive markets, emphasis will be on quality and service."

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Mud Products Appoints Equipment Division Representative at Houston

Mud Products, Inc., Tulsa, has named E. W. Parker to head the firm's equipment division in the Houston area.

E. W. Parker

Parker served with Hinderliter Tool Company and United Supply Company in Houston and the Gulf Coast area for many years. With Mud Products, he will service and advise on mud handling problems.

Parker replaces Sam Dyer, resigned.

Thomas J. Williams Is Appointed Edward Valves Sales Engineer

Thomas J. Williams, Houston, has been appointed sales engineer in the southwestern states by Edward Valves, Inc., East Chicago, Ind.

Thomas J. Williams

Williams holds a degree in petroleum engineering from Louisiana State University. He was formerly employed by Pate Drilling Company in Texas and previous to that had experience with The Texas Company. During the war he served in the Army Air Force, spending over two years in the South Pacific. Recently he participated in a training program at the Edward home office in East Chicago.

Williams will make his headquarters in Tulsa with the Rockwell Manufacturing Company.

Herbert J. Rowe, graduate of the University of Illinois, has been made sales engineer for the Great Lakes region. He was trained in the sales department of the home office in East Chicago, where he will make his headquarters.

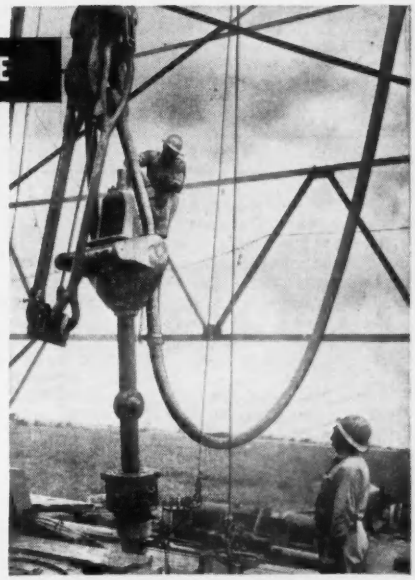
Bethlehem Announces Appointments

Bethlehem Supply Company announced the following personnel changes: C. V. Hush, former clerk in the Tubular Sales department, Tulsa, transferred to the Dallas sales office and promoted to chief clerk; H. C. Hoggard named field representative at Borger, Texas; B. M. Quigley, field representative, transferred from Odessa to Sundown, Texas; J. W. Strickland and P. W. O'Brien, have been appointed store manager and field representative, and assistant store manager, respectively, of Bethlehem's new supply store at Elk City, Okla.

AT THE DERRICK, THE HOSE YOU DEPEND ON IS

HEWITT-ROBINS

ROTARY DRILLING HOSE



You can't buy better hose for oil well drilling . . . it's made by men who know their job! Hewitt built-in, leak-proof couplings assure an unrestricted, rubber-lined fluidway *all the way;* the high tensile duck carcass is heavily wire-reinforced to withstand extreme pressure, yet the flexibility you want is there; the tough Hewitt cover resists stripping action and abrasion. Whether you choose Monarch for deep well work, Ajax for medium depth drilling, or Conservo for the short holes, you get increased efficiency, lower operating costs, *longer useful hose life.*

MUD PUMP SUCTION HOSE

Best way to cut suction costs is to let Hewitt-Robins help! With Hewitt Mud Pump Suction Hose you prevent hose collapse and kinking because the carcass is reinforced with spiraled spring steel wiring. Built-in, clampless nipples are permanently sealed in the hose—and over everything is a rugged cover that's tougher than all the abuse it will ever get!

ROTARY FLEXIBLE HOSE

Another example of Hewitt-Robins oil-industry specialization. Used between the discharge end of the pump and the end of the standpipe line, Rotary Flexible Hose permits quick relocation of the line without disturbing the pump. It is an excellent vibration dampener and, unlike rigid pipe, it *won't crystallize.*

* * *

For full information on these and many other Hewitt-Robins hoses for the oil industry, call your Hewitt Rubber distributor, listed in the classified telephone directory, or write us.

HEWITT RUBBER DIVISION

HEWITT-ROBINS INCORPORATED

240 KENSINGTON AVENUE · BUFFALO 5, N. Y.

WORLD OIL'S Trading Post

CLASSIFIED ADS

SERVICES · PERSONNEL · USED EQUIPMENT

RATES: Regular Classified (undisplayed) set in this size type: 10 cents per word. If Box Number is to be used count an additional six words. Replies forwarded without charge. Situation Wanted: 5 cents per word. Display advertisements, set in suitably larger type with ruled border: $9.00 per column inch per insertion. Situation Wanted: $4.50 per column inch. **All classified ads payable in advance.** 10% Discount if 3 or more insertions are ordered at one time. **COPY DEADLINE:** 5th of month preceding date of issue. Send copy and checks to: Trading Post Section, World Oil, P. O. Box 2608, Houston, Texas.

FOR SALE

■ **ROTARY equipment almost new, only used few days, 1800' PK rods, Drill collar 30'x4¼" with 3½" box, King water swivel 1¼", PK slips, hoist plugs, overshot. Complete outfit $4500 or will divide. We handle new and used spudders, rotaries, core drills, pipe, tools, cable. Fishing tools and equipment rented. Pressey & Son, Pueblo, Colo.**

■ Beech Bonanza for sale, standard equipment including extras. Zero hours on engine. 670 hours on airplane. Contact Bill Sidwell, Husky Refining Company, Box 380, Cody, Wyoming, Phone 500.

■ Askania Magnetometer for sale. Square case type with numbered scale, 180 stop in base of instrument, and temperature-compensated system. Instrument completely refinished. Tripod, compass, and mahogany case are new. Price $1075.00 Robertson Instrument Company, 5022 Ennis Street, Houston 4, Texas.

Will consider leasing several 80,000 barrel steel tanks for sweet crude storage at Mexia, Texas.

We also have steel storage tanks for sale as follows:

7—55,000 bbl., Maud, Oklahoma
15—80,000 bbl., Hominy, Oklahoma

For further information write Stanolind Oil Purchasing Company, Attention L. M. Jones, Box 591, Tulsa, Oklahoma.

Power barge, steel, 28'x94'x10', steel house, equipped with three 9x12 8-eye National Superior diesels and one LI-600 Cummins diesel, with generating capacity of 1050 KW. All necessary auxiliary equipment. Located LaPorte, Texas. For inspection contact W. Teer, Purchasing Department, Humble Oil & Refining Company, Houston, Texas.

FOR SALE: Two new welded propane tanks tested 200# cold water pressure, suitable for either propane or butane. Size 54" diameter x 37' 6" long, mounted on welded oil field skids, complete with fittings. Tanks never used, located Southern Louisiana. Offered at bargain price. Wire or phone Bethlehem Supply Company, Tulsa, Oklahoma.

Two 32 foot by 1¼" diameter BORESCOPE complete with transformers and box . . . Extra heads, tubes, guides and lens. First class condition. $500 each. Engineering & Development Company, PR-9968, 5513 Clinton Drive, Houston, Texas.

NOTICES

■ **Potential oil land for lease, 300 yds. from 3700 ft. producing well. Want development. Write Frank Stanush, 1040 Chicago St., New Braunfels, Texas.**

SITUATIONS WANTED

Experienced Office and Credit Management, Purchasing Sales, Personnel and Administrative Work. Industrial and Oil Field Supplies. Presently employed in Houston but willing to move. Seek greater responsibility and opportunity. Excellent references. Write Box 67W, c/o World Oil, Houston, Texas.

We are interested in capital and technique for the proper development of large and promising shallow oil field in Jarahueca, Cuba. A visit to the field would result most convincing. Write: Cia., Perforadora de Santa Clara, S. A., 158 Morro St., Habana, Cuba.

LEASES, DRILLING, ACREAGE, ETC.

■ Will invest in Producing, semi-proven or wildcat royalties. Write details Box 546, Thibodaux, La.

■ What RECORDS are there on file IN THE CAPITAL CITY OF TEXAS that you would like to have COPIED? OIL & GAS? LAND? GEOLOGY? LAW? Get these copies on MICROFILM! MICROFILM SAVES 95% FILE SPACE! MICROFILM COSTS 80% LESS THAN TYPING OR PHOTOSTATS! FAST? Yes!: 500 pages per hour. Complete Microfilm and Library Research Service! Sterling R. McLean Co., 3115 Guadalupe St. Austin, Texas.

HELP WANTED

Party Chief

A highly regarded, long-established, growing geophysical company is looking for the best party chief available.

Successful applicant must have a college degree and at least five years' experience as a seismic party chief. He must be a highly skilled interpreter and must be widely and favorably known in the industry.

He must have the vision to recognize a unique opportunity and the courage to take advantage of it. This is not an ordinary job, to be filled by an ordinary man—the rewards will be in keeping with the individual's competence and capacity.

If you are interested and think you can qualify, write giving full particulars including age, education, experience and salary expected. If available, please enclose a small photograph. Our employees know of this ad.

Replies will be held in strictest confidence. Address: Box 69W, c/o World Oil, Houston, Texas.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Petroleum Management Firm Offers Consulting and Appraisal Service

S. R. (Pat) Casey, Jr., Herb Von Eiff and Louis L. Seiffert, Jr., have resigned from Woodley Petroleum Company and have formed Petroleum Management Company, with offices at 913 Electric Building, Houston.

The new organization will continue to do Woodley's geological work in the Gulf Coast area as consultants. It will specialize in appraisal and consulting work, as well as geological, engineering and managerial service.

The partners have also organized the Livingston Drilling & Well Service, Inc.

Engineer Joins Nelson Electric Sales Department at Tulsa

John H. Elsloo, electrical engineer, has joined the Sales department of Nelson Electric Manufacturing Company, Tulsa, as a sales engineer. A graduate of the University of Oklahoma, he is representing the company in central Oklahoma, southern Kansas and the Tulsa area.

John H. Elsloo

Previously, Elsloo was with Wells-Surveys, Inc., and the U. S. Engineers. He spent four years with the U. S. Air Force during World War II.

Field Service Salesman Assigned

L. T. (Tater) Ferguson will represent The Guiberson Corporation as field service salesman in Illinois, Indiana and Kentucky. Ferguson has been with The Guiberson Corporation for seven years, having previously been located in Dallas and Odessa, Texas.

Larkin Reopens Warehouse

The Larkin Packer Company, St. Louis, reopened its warehouse in Oklahoma City. A complete stock of all Larkin products will be carried to serve distribution points in Oklahoma and Southern Kansas.

Charles E. Pollard Transfers

Charles E. Pollard has been transferred from Brookhaven, Miss., to Oklahoma City as assistant district superintendent for Houston Oil Field Material Company.

Mud Control Representative Named

J. G. McKenney, formerly with Dowell Incorporated and Mud Products, Inc., has been appointed sales engineer and representative for Mud Control Laboratories, Oklahoma City.

New Books, Maps and Movies

Oil and Gas Field Maps

Basic information with maps for Texas, Louisiana, New Mexico, South Arkansas, Mississippi and western Alabama is contained in the "Oil and Gas Field Index and Factual Data Book." All oil and gas and distillate fields are shown alphabetically with the county and district. Included also are offshore plats showing blocks, wells, and company owning lease with bonus paid.

The 250-page volume gives information on approximately 2500 oil and gas fields.

L. J. Wilson Map Company, P. O. Box 6277, Houston 6, $20.

Oklahoma Conservation Laws

State laws governing the production of oil and gas are discussed in detail in the two-volume "Oklahoma Oil and Gas Conservation Laws," prepared by Reford Bond, chairman, Ray O. Weems, vice chairman, and Ray C. Jones, member, Oklahoma Corporation Commission.

The first volume contains the constitutional and statutory provisions under which the Commission is authorized to conserve oil and gas. Each section of the constitution and statute is annotated to all the decisions of the Oklahoma Supreme Court, the federal courts, and the U. S. Supreme Court. The volume also treats of unitization, oil and gas pipe lines, regulation and inspection of wells, dealers in equipment and material, trade marks, names and brands, rules and regulations of the Commission, forms, historical notes and an index.

Oil and gas conservation orders are discussed in the second volume, which contains orders issued by the Commission from 1946 to 1949.

Co-Operative Publishing Company, Guthrie, Okla., each volume, $15; both volumes, $25.

Gas Lift

Results of experiments by the Texas Engineering Experiment Station from September, 1942, to May, 1945, are embodied in "Flow Characteristics of Gas Lift in Oil Production," Bulletin 113 of the Agricultural and Mechanical College of Texas.

In the experiments, tests were made of the productive capacities of several diameters of pipe of various lengths when lifting oil and water by means of air lift. Author S. F. Shaw includes air and gas lift nomenclature, and treats of methods used in conducting the tests, facilities and equipment used in the experiments, pipe arrangements, significant rates of flow, and influence of back pressures on capacities of flow pipes.

Texas Engineering Experiment Station, College Station, Texas.

Secondary Recovery

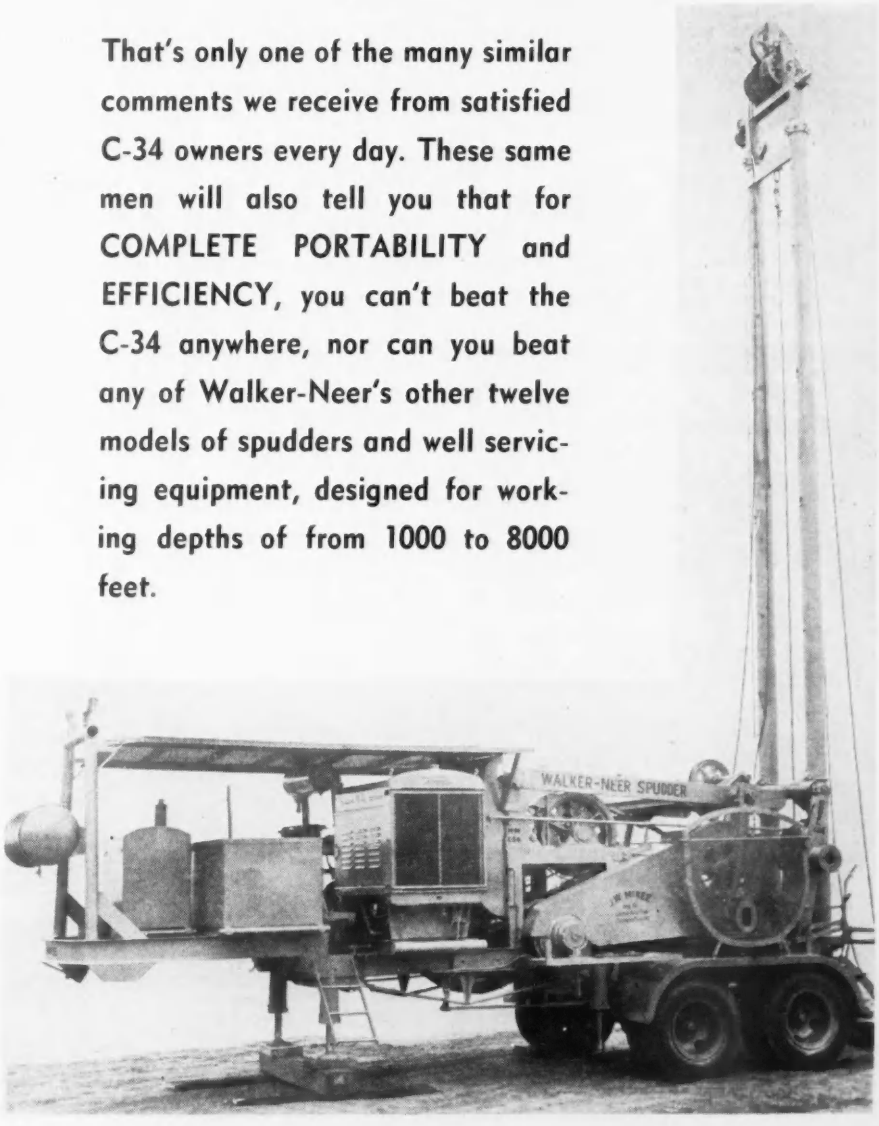
A new textbook, "Secondary Recovery of Oil," covers the two widely used methods of secondary recovery, water-flooding and injected gas drive. The practices cited are those of the eastern oil producing district, although the fundamental principles may be applied to any producing district that is operating with these two methods.

Subject matter includes Geological Factors Influencing Secondary Recovery; Predicting a Reservoir's Susceptibility to a Water Flood; Well Spacing and Flood Patterns in Water Flooding; Water Source and Purification; Design and Construction of Water Pumping Plants; Development and Operation of Water Flooding; Correcting a Heterogeneous Permeability Profile; Reconditioning Wells in Water-Flooding; Estimating Costs of Water-Flood Projects; Predicting a Reservoir's Susceptibility to an Injected Gas Drive; Factors Affecting Oil Recovery in an Injected Gas Drive; Well Spacing and Well Patterns in Injected Gas Drive; Design of Injected-Gas-Drive Plants; Development and Operation of Injected Gas Drive.

Mineral Industries Extension Services, The Pennsylvania State College, State College, Penn., $4:50.

"FINEST IN THE FIELD"

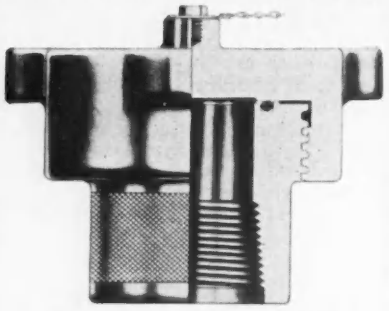
That's only one of the many similar comments we receive from satisfied C-34 owners every day. These same men will also tell you that for COMPLETE PORTABILITY and EFFICIENCY, you can't beat the C-34 anywhere, nor can you beat any of Walker-Neer's other twelve models of spudders and well servicing equipment, designed for working depths of from 1000 to 8000 feet.



WALKER-NEER MACHINE CO.

WICHITA FALLS, TEXAS

2-PIECE
BLANKING PLUG UNION



FOR OIL, GAS, MUD, WATER OR STEAM

Greater convenience and greater economy is provided by Yale **(2-Piece)** Blanking Plug Unions. Utilizing time-proved, positive sealing O-Rings, they're designed for any service in the drilling, producing, pipe line and refining industries where blanking plug unions are required. Available from 2" through 16", with larger sizes on special order. All sizes can be furnished with hinged caps when specified.

YALE MACHINE WORKS

4403 Yale Street Houston, Texas

Export: R. S. Stokvis & Sons, Inc., 17 Battery Place, New York, N. Y.

HEAVY DUTY-RUGGED....

You can maintain your required speed for the full period of the test with much less effort. Curtin centrifuges, proven world-wide, are heavy duty, rigidly constructed, and extremely simple in design. Illustrated bulletin, giving full details, available upon request.

W·H·CURTIN & CO.

HOUSTON .... NEW ORLEANS

SQUEAKS from the BULLWHEEL

Un-*Fortune*-ate Situations

"At Stettler, on the plains, about 100 miles southeast of Edmonton, Gulf recently brought in an oil well in the Devonian D^2 and D^3 at 5300 feet. This well has a daily potential of 3000 barrels and may indicate the presence of an oil field."—From "Canada's Oil Frontier" in January *Fortune*.

• It **would** be a bit surprising if there weren't an oil field here!

"Far to the south in the foothills of the Rockies, Gulf again has brought in the deepest well in Alberta at Pincer Creek. This well, from 12,400 feet is capable of yielding 83 million cubic feet of gas and 3000 barrels of condensate. Further drilling may reveal oil."—From "Canada's Oil Frontier" in January *Fortune*.

• They seem to be pretty hard to please in Canada.

"The little independent, nevertheless, still finds it hard to get hold of land that has oil underneath."—From "Canada's Oil Frontier" in January *Fortune*.

• This same difficulty has bothered American operators from time to time during the past 91 years!

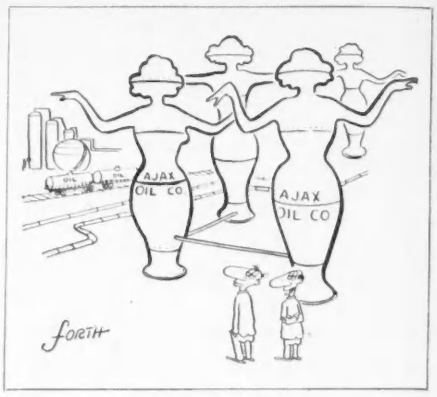
Gimme Time!

A small boy was seated on the curb with a pint of whiskey in his hand, reading *Esquire* and smoking a big cigar. An old lady passed and asked, "Little boy, why aren't you in school?"

The infant replied, "Dammit, lady, I ain't but four!"

Bad Policy

A farmer's barn burned down and the agent for the insurance company, explaining the policy that covered the structure, told him that his firm would build another barn of similar size instead of paying the claim in cash. The farmer was furious. "If that's the way your company does business," he exploded, "you can just cancel the insurance on my wife!"



"Our new type storage tanks have increased the interest of our employes!"

Another Texas Story

A Boston salesman visited Texas and heard a Texas partisan boasting, as usual, about the heroes of the Alamo who almost alone, held off whole armies.

"I'll bet you never had anybody so brave around Boston," challenged the Texan.

"Did you ever hear of Paul Revere?" asked the Bostonian.

"Paul Revere?" said the Texan. "Isn't that the guy who ran for help?"

Turnaround

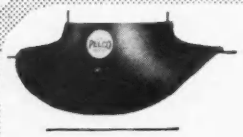
A worm met another worm coming up from the ground and declared, "You're very beautiful and I'd like to marry you."

"Don't be a dope," was the reply. "I'm your other end."

Spectrum Spectacle

Her car stalled at the corner, and the traffic light kept changing—red, yellow, green, red, yellow, green.

The policeman stepped over to the car and asked in a hurt voice: "What's the matter, lady, ain't we got any colors you like?"



Specify **PELCO** Welding Saddles

PELICAN WELL TOOL & SUPPLY CO.

P. O. Drawer 1108
Shreveport (84), La.

SEE YOUR NEAREST SUPPLY HOUSE

10 GOOD REASONS WHY OPERATORS PREFER

McCullough GUN PERFORATOR SERVICE

1. **MEETS EVERY CONDITION.** Guns fired either electrically or mechanically: guns run on cable, sand line, drill pipe, tubing, or on piano-wire measuring line in extremely high-pressure wells.
2. **SIMULTANEOUS FIRING** under all conditions gives exact spacing of shots, perfect perforation pattern, and saves down-the-hole time.
3. **ACCURATE DEPTH MEASUREMENTS** put the shots right where you order them.
4. **MAXIMUM PENETRATION** of bullets into the formation, as proved repeatedly in competitive field tests.
5. **GUNS TO FIT EVERY CONDITION.** McCullough employs more than 30 different types and sizes of guns.
6. **ALL SIZES OF BULLETS** from $\frac{1}{16}$" dia. up to $\frac{3}{4}$" dia., to fit every possible need.
7. **BURRLESS BULLETS,** giving a completely burr-free hole, eliminating casing scraping, with *no* sacrifice of penetration.
8. **NO LOST TIME.** McCullough's simpler, lighter equipment cuts setting-up and moving-out time, speeds up every job.
9. **EXPERIENCED MEN.** With years of experience behind them, thoroughly-trained McCullough gun-perforating crews do their jobs quickly, efficiently, safely.

These Are Some of the Reasons Behind the Proven Fact That

McCullough

PUTS THE SHOTS WHERE THEY COUNT!

McCullough TOOL COMPANY

5820 South Alameda St., Los Angeles 11, California
405 McCarty Avenue, (P. O. Box 2575) Houston, Texas

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TEXAS: Alice, Houston, Cisco, Corpus Christi, McAllen, Odessa, San Angelo, Tyler, Victoria, Wichita Falls. **OKLAHOMA:** Oklahoma City, Guymon, Healdton. **MISSISSIPPI:** Laurel. **NEW MEXICO:** Hobbs. **KANSAS:** Great Bend. **CALIFORNIA:** Los Angeles, Avenal, Bakersfield, Ventura. **MONTANA:** Cut Bank. **LOUISIANA:** Houma, Lake Charles, New Iberia. Shreveport. **WYOMING:** Casper, Cody. **CANADA:** Edmonton. **VENEZUELA:** United Oilwell Service. **S. A.:** Caracas, Anaco, Maracaibo.

EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y.

Flashes from the BEACON

AMONG THE MOST popular features in the BS&B BEACON 1949 volume was the "Parade of Cities" series which started with Oklahoma City, and paid tribute to "big towns" of the Middlewest, South, and Southwest. Even people **not** connected with the Chambers of Commerce in question wrote in for extra copies.

* * *

"Oh, cheer up, Hanley! We don't hold it against you because you failed in one sale out of 105 last year . . . Just make up your mind to do better this year!"—a BEACON *Original* by Dave Hunt.

* * *

So (knowing a good thing when enough people point it out to us) we're continuing the Parade of Cities in 1950. The March issue will carry the story of Wichita, Kansas . . . the State's medium-sized city with a metropolitan attitude. Chauncey Black spent enough time with Wichitans who were either old-timers themselves or only memories removed to come up with a rip-snorter on this one. . . .Watch for it.

* * *

OIL MEN have taken this "different" company magazine to their hearts so completely, that they are writing for copies for their friends.

* * *

YOU MAY GET your own issue of the BS&B BEACON every month with practically no effort. Just a line on your company letterhead will do it.

Write to:

BLACK, SIVALLS & BRYSON, INC.

Industrial and Public Relation Division

720 Delaware

Kansas City, Missouri

SQUEAKS from the BULLWHEEL

Liberal Education

A tractor salesman approached a prosperous looking farm, where he observed the farmer slowly and painfully guiding a plow drawn by a bull. Thinking that this offered an excellent opportunity for a sale, he pointed out to the farmer the many advantages of a tractor.

To his surprise, the farmer said that he already had a tractor, that it worked fine, and was at present in the barn. On his query as to why the bull was being used for plowing, the farmer replied:

"Son, I aim to teach this critter that there's something in life besides romance."

Well Grounded Opinion

"My father was a conductor—in fact, he was too good a conductor."

"Railroad? Orchestra?"

"Neither one—he was struck by lightning."

Sounds Fishy

Teacher (talking about the dolphin and its habits): "Just think! A single dolphin will have 2000 baby dolphins."

Little Girl: "Goodness! And how many do the married ones have?"

A Hell of a Story

Once upon a time the fence between Heaven and Hell broke down. St. Peter appeared at the broken section and called out to the devil: "Hey, Satan, since all the engineers are over in your place, how about getting them to fix this fence?"

"Sorry," replied Satan. "My men are all too busy to go about fixing measly fences."

"Well, then," replied St. Peter, "I'll have to sue you if you don't."

"Oh yeah," countered the devil, "and where are you going to get a lawyer?"

She's Ruined, Either Way

A large and wild-eyed rooster was chasing a hen. The hen dodged hysterically to escape his advances and dashed into the roadway, directly into the path of a truck. Two old maids, seated on the porch, witnessed the tragedy.

One pointed to what was left of the hen, nodded her head virtuously, and said to the other: "You see! She'd rather die!"

The Golden Commodity

Maybe the reason older people are more quiet than younger people is because they have a lot more to be quiet about.

You Cad, Sir!

Joe had the granddaddy of all hangovers and requested succor from his good friend, the bartender. "What'll it be?" asked the barkeep.

"Oh," said Joe, "tall . . . cold . . . and full of gin."

A drunk on the next stool straightened up and said: "Sir, you speak of the woman I love."